Macroeconomic assessment for the EU 'Climate Action and Renewable Energy Package'

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Abstract: This paper propose an assessment for European Commission '*Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020'*, that was agreed the 23 January 2008. The policy assessment uses macroeconomic modeling tools: NEMESIS economic macro-econometric model, for which additional developments were needed to be able to implement strictly the directive proposals includes in EU 'Energy and Environment' package. A new module for energy demand and environment was developed to extend from EU-15 to EU-27 NEMESIS set of energy and environment indicators, with also an extension for biomass (including biofuels) and all renewable categories. The focus puts on the economic consequences in 2020 of the joint implementation of the 'EU ETS review', 'non ETS effort-sharing' and 'renewables' directive and decision proposals. Different scenarios are explored depending on the way auctioning revenues are recycled by States, and compared on the basis of economic and environmental efficiency criteria defined by the Commission. In Scenario S1, auctioning revenue is kept by states and is used for decreasing national debt. There is no recycling through public investment or revenue redistribution to private agents. In scenario S2, the revenue of auctioning in the EU ETS sector is recycled through an equivalent reduction, in terms of revenue, of employers' social contribution rate. In scenario S3, auctioning revenue is recycled in two ways: A reduction, as in scenario S2, of employers' social contributions rate, and a general subsidy to private R&D expenditures up to 30 %. The R&D subsidy in calculated first, and only the difference between auctioning revenue and R&D subsidies is used to reduce employers' social contribution rate. The main important results are that the implementation of EU *Climate Action and Renewable 1Energy Package* should have only a limited cost in terms of GDP for EU-27, or even a negative one, depending the way auctioning revenues are recycled by Member States; important gains could be obtained for consumers if recycling of auctioning revenue is used to increase households' disposable income; employment could also be importantly stimulated if the recycling of revenue, and the stimulation of households' final consumption, passes through a reduction of labor cost and not by an increase in social transfers that could impact negatively on European firms competitiveness; and lastly the application of the community solidarity principle could EU *Climate Action and Renewable Energy Package* represent an important opportunity for growth and employment in EU countries with GDP below European average like Romania and Poland, that are also very carbon intensive.

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Introduction

European Commission agreed the 23 January 2008 a 'Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020'. This 'Climate Action and Renewable Energy Package' contains the following proposals:

- a directive amending directive 2003/87/EC so as to improve and extend the EU greenhouse gas emission allowance trading system ('EU ETS review');
- a decision on the effort of EU member states to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020 ('non ETS effort-sharing');
- a directive on the promotion of the use of renewable energy sources ('renewables directive');
- a directive on the geological storage of carbon dioxide ('CCS directive').

These proposals, accompanied with impact assessments, establish a set of key principles for EU post-Kyoto policy over the period 2011-2020 and beyond, with two main targets for 2020, already defined in the energy and climate change package adopted by the Commission the 10 January 2007:

- an independent EU commitment to achieve a reduction of at least 20 % in the emission of greenhouse gases by 2020 compared to 1990 levels and the objective of a 30 % reduction by 2020, subject to the conclusion of a comprehensive international climate change agreement;
- a mandatory EU target of 20 % renewable energy by 2020 including a 10 % biofuels target.

This strategy was endorsed both by the European Parliament and by EU leaders at the March 2007 European Council. The 'Climate Action and Renewable Energy Package' adopted the 23 January 2008 by the Commission is a concrete set of proposals to reach these targets, including how efforts could be shared among Member States. In particular:

- the 'EU ETS review' aims at increasing the efficiency and the scope of the EU ETS, notably by including chemical and air transport sectors and by decreasing the emissions caps[1], with an reduction objective of 21 % for CO_2 emissions in 2020, compared to 1990;
- the 'non ETS effort-sharing' aims at sharing the emission reduction effort amongst member states in the sectors not covered by the EU ETS in order to reach the EU's 20 and 30 % emission reduction commitments. The proposal is based on efforts by member states on the principles of growth, fairness and solidarity;
- the 'renewables directive' aims at promoting the use of energy from renewable sources by setting national targets ensuring that the share of renewable energy in EU final energy consumption reaches at least 20 % by 2020;
- the CCS directive aims at allowing and regulating the capture of CO_2 from industrial installations and its storage into a suitable geological formation.

[1] The EU introduced from 2005 to 2007 the first phase of the EU-ETS, corresponding to the NAP1 commitments on emissions, that resulted in a very low carbon price due to too high emission caps. Thereafter the EU agreed from 2008 to 2012 the second phase of EU-ETS, with tougher objectives on GHG emissions reductions.

The ‘Climate Action and Renewable Energy Package’ aims thus providing EU, up to 2020, a strategy for increasing the use of renewable energies and developing incentives towards clean production technologies through a reform on the EU ETS. This strategy will also strengthen EU energy security of supply and preserve economic growth.

Compared to 2005, the last year for GHG emissions measurement by European Environment Agency[2], the ‘Climate Action and Renewable Energy Package’ represents a 10.8 % reduction of GHG emissions in Europe, in the case of an unilateral commitment of European countries on GHG emissions, and 20.8 % in case of an international climate change agreement (and respectively 13.7 % and 23.7 % compared to projected emissions levels for 2020). It recommends consequently investing at least 20 % of the revenues derived from GHG taxes and auctioning in strategic sectors for climate change (such as specific R&D, renewable energies, forestry and land use, energy savings in buildings, etc.).

The main objective of this paper is now to provide an assessment with the NEMESIS model (*New Econometric Model for Evaluation by Sectoral Interdependencies and Supply*) of this EU ‘Climate Action and Renewable Energy Package’. The focus is put on the economic consequences in 2020 of the joint implementation of the ‘EU ETS review’, ‘non ETS effort-sharing’ and ‘renewables’ directive and decision proposals. Different scenarios are explored depending on the way auctioning revenues are recycled by States, and compared on the basis of economic and environmental efficiency criteria defined by the Commission. A special emphasis is also put on the influence of technological change on economic and environmental indicators in the different scenarios studied with NEMESIS. NEMESIS includes an endogenous R&D decisions module, and this feature of the model is actually important to assess for climate and energy policies, which induce substitution and revenue effects, but come also modify R&D investment decisions of agents and the rate and direction of technical change.

The presence of endogenous technical change in NEMESIS is also important to underline for the reason that it can modify the cost of the policies assessed previously with other models where technical change is considered exogenous, as for the impact assessment[3] accompanying the EU ‘Climate Action and Renewable Energy Package’. The measured cost is generally lower when technical change is endogenous, as firms’ have an increased reaction capacity to the introduction of a carbon value; they can do substitutions but also, and that is a novelty of NEMESIS, modify the rhythm of technical change. Also, the presence of endogenous technical change in NEMESIS allows new evaluations of Kyoto policies, grounded on R&D and knowledge. This paper gives notably an example of GHG emissions reduction policy implemented by combination of carbon taxation and tradable permits (in order to fight the negative environmental externalities) and of subsidies to R&D (in order to promote positive knowledge and productivity externalities).

The first part (section 2) of this paper is a methodological one. It begins with a presentation of the modelling tools used, notably a module for energy demand and GHG emissions that was developed specially for this impact assessment. Then the way the ‘Climate Action and Renewable Energy Package’ was implemented in the modelling

[2] ‘Greenhouse gas and emission trends and projections in Europe 2007’, EEA report, N° 5/2007.

[3] see SEC(2008) 85/3.

tools is detailed. The second part of this paper (section 3) presents the baseline scenario. It describes in details the evolution of the main energy and environment indicators from 2005 up to 2020. It explains also that, to render things comparable, common assumptions with the version of PRIMES model used to realized the impact assessment joined to the EU climate and energy package where used, especially for the structure of energy supply, and renewable energies penetration rates. The third part (section 4) comments the main results of the scenarios, at EU, national and sectoral levels, of the three scenarios assessed for: S1 with no recycling of auctioning revenues, S2, with recycling of auctioning revenues with a cut in employers social contributions rate and S3, that combine a recycling with a cut in employers' social contribution rate, similar to S2, with a subsidy to firms' R&D. The fifth section of this paper concludes, notably by comparing the results of the assessment realized with NEMESIS, to the assessments already presented by Commission staff[4]. An appendix gives finally additional detailed results for EU-27 countries.

1- Modeling tools and scenarios implementation

The assessment of the 'Climate Action and Renewable Energy Package' requires adapted modeling tools, with notably the following characteristics:

1- detailed sectors distinguishing EU ETS and non EU ETS;
2- detailed energy products and power sector, allowing in particular calculating the share of renewable in final consumption and biofuels share in transports fuels use;
3- GHG emissions calculation (CO_2 and other);
4- EU ETS representation with endogenous determination of carbon values and auctioning revenue;
5- recycling possibilities of auctioning and carbon taxes revenues, for example with equivalent reduction of direct taxation of firms or households, cuts in employers' social contribution rate, subsidies to firms' R&D expenditures, etc.

Some of these characteristics where not, or only incompletely present in NEMESIS, at the beginning of FORASSET project, principally for point 2 to point 4 above. This has implied to adapt NEMESIS modeling system and then to establish an implementation protocol of the 'Climate Action and Renewable Energy Package' in the model, as explained below.

1.1- Presentation of modeling tools

NEMESIS model is composed of two main components:

- a large scale economic macro-econometric model, the 'core' of NEMESIS[5], designed for EU-27 countries (with the exception of Cyprus and Bulgaria for which data are missing) plus Norway, to which a set of optional or satellite modules can be added for Agriculture, Land-Use and NUTS-2 regions, which account altogether about 200.000 equations and calculated variables;
- a detailed technico-economic model for EU-15 countries, NEEM (NEMESIS Energy Environment Module) of about 100.000 equations, which is a partial

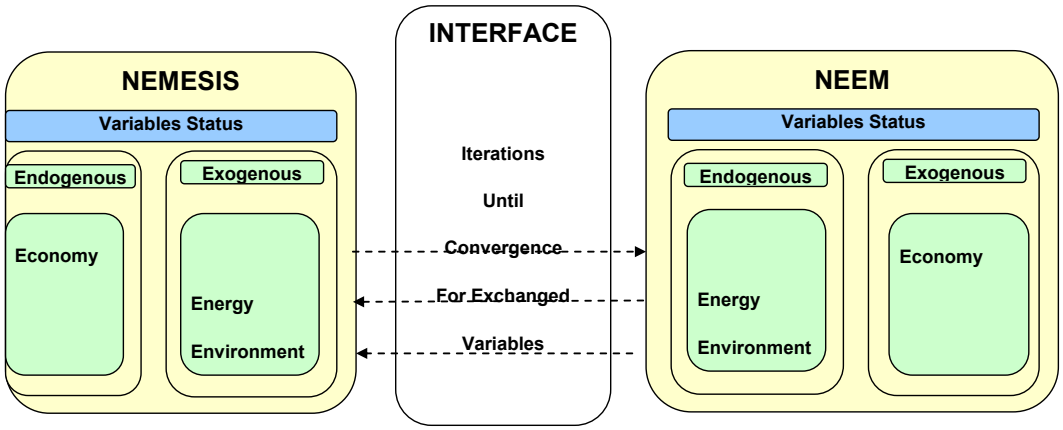
[4] see footnote 3 and annex to impact assessment SEC(2008) 85 Vol.II.

[5] see NEMESIS web site: www.erasme.ecp.fr/NEMESIS.

equilibrium model for energy demand and supply, and GHG emissions calculation, developed by National technical University of ATHENS (NTUA).

NEMESIS core economic model can be linked to NEEM through an interface that exogenizes in NEMESIS the energy/environment variables calculated by NEEM. During a policy simulation exercise, NEMESIS and NEEM exchange, as described on figure 1, variables that are endogenous in one model (energy/environment in NEEM economic in NEMESIS) and exogenous in the other, with iterations that stop once the value of the variables exchanged in the interface do not modify any more between the *n* (convergence attained) and *n-1* iterations, or change with a percentage inferior to a predefined convergence criteria.

Figure 1: Functioning of Interface between NEMESIS and NEEM



The linkage between NEMESIS and NEEM was in this way used previously to assess for different efficient scenarios on carbon taxation policies for EU ETS and non EU ETS sectors. But NEEM was developed for EU-15 countries only, and the assessment for the EU 'Climate Action and Renewable Energy Package' presented here, needed to be realized at EU-27 level. Furthermore, it was not foreseen in FORASSET description of work, to extend NEEM to EU-12 countries, and no budget was allocated for this task. For these reasons, it was decided by the ERASME team to develop, with the help of NTUA, a new energy/environment module limited to energy demands and substitutions system, and GHG emissions (CO_2, CH4, N2O, SF6, HFC and PFC) that was included directly in NEMESIS core economic model, as a new optional module.

The key characteristics of this NEMESIS Optional Module for Energy Demand and Environment (NOMEDE) were designed following the 5 items list above, and allows accounting for the main objectives, targets and sub-targets of the EU 'Climate Action and Renewable Energy Package'. It calculates notably, for each EU-27 country (except Cyprus and Bulgaria), the renewable share in final energy consumption and the share of biofuels in gasoline and diesel used by transports sector. It can also compute the share of renewable in power generation sector.

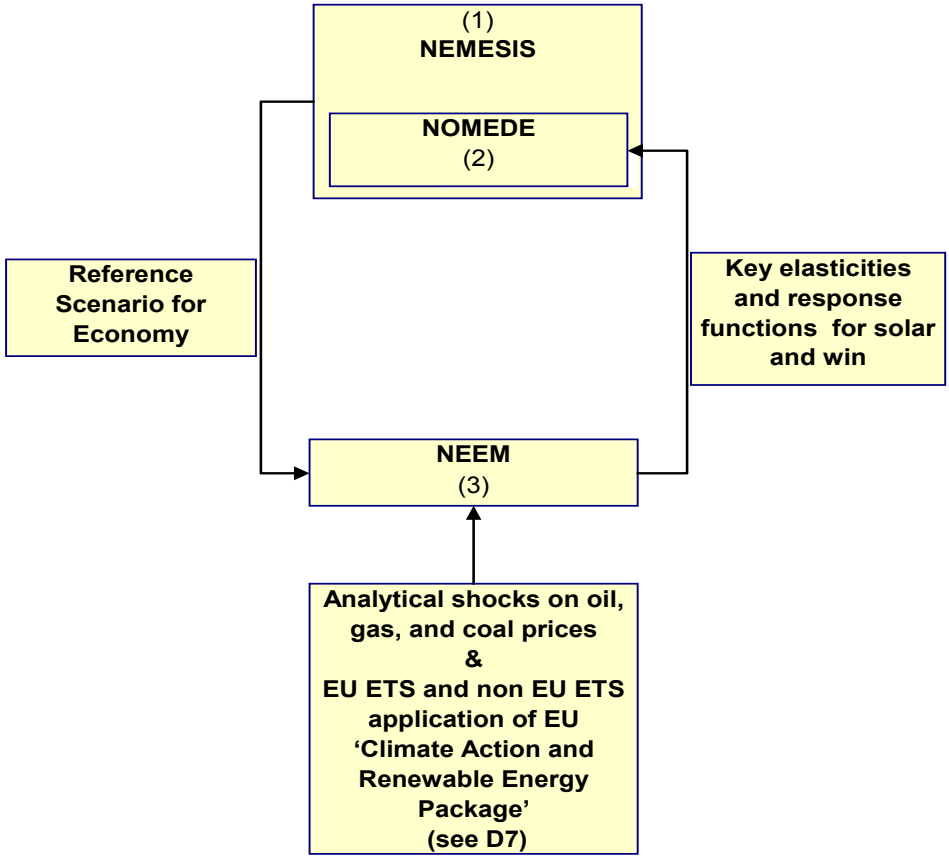
NOMEDE was based on EUROSTAT data for energy products (Coal, Gas, Petrol, and Electricity), biomass (Biofuels, Biogas, Wood and Wood Wastes) and Urban Wastes, and on European Environmental Agency for GHG emissions data. It is more detailed that NEEM, that do not includes biomass, for energy demand categories, but is less detailed in the area of energy demand and supply technologies.

For energy demand, NOMEDE takes the global quantities calculated by NEMESIS core economic model from the 30 production functions of NEMESIS sectors and

households energy consumption categories (Coal, Gas, Petrol, and Electricity), and calculates energy demand by product, including biomass categories, and energy prices, that are sent back to NEMESIS. Energy supply in then determined by NEMESIS production functions for energy sectors, on the basis of energy demand by product calculated by NOMEDE, and energy import and export functions included in NEMESIS. For the power sector, response functions, derived from NEEM simulation exercises (see figure 2), allow calculating the shares of solar and win, while geothermal, hydraulic and nuclear production capacities were considered exogenous, and were based on PRIMES latest projections[6] for EU DG-Trend.

NOMEDE includes finally a tradable permits module, that cans implement endogenous carbon taxes and simulate different tradable permit systems (free allocation, full auctioning and combination of the two, as in the EU 'Climate Action and Renewable Energy Package'), and different taxes and auctioning revenue-recycling scheme.

Figure 2: NOMEDE calibration procedure



For policy experimentations, NOMEDE baseline was partly calibrated onto PRIMES results. It was the case for renewable share evolution in power generation sector and electricity production from Geothermal, Hydraulic and Nuclear sources. For biofuels share in gasoline and diesel. For fuel inputs in power generation sector and fuels' efficiency factors in power generation and in transport sector (passengers and freight).

Consequently, NOMEDE allows calculating in baseline energy consumptions and GHG emissions close from PRIMES model, that was already used to assess for EU

[6] "Energy and Transport: Trends to 2030 – Update 2007", European Commission/ Directorate-General for Energy and Transport.

'Climate Action and Renewable Energy Package' together with GAINS, GEM-E3, PACE and POLES models. This presents the advantage that the differences in results between the assessments presented here, and the previous assessments that were performed for the commission, can be attributed to these discrepancies in model mechanisms and in policy assumptions, not to baseline evolutions.

1.2- Implementation protocol of 'Climate Action and Renewable Energy Package' in modeling tools

Modeling tools presented in the preceding section 2.1, with NOMEDE included in NEMESIS were then used to assess for the EU 'Climate Action and Renewable Energy Package'. This section 2.2 details now the protocol used to proceed to this assessment that can differ from previous assessments achieved for the Commission (SEC(2008) 85 Vol. II) on several points:

1. for GHG emissions reduction, only the 20 % target for 2020 compared to 1990 levels was studied, for the reason that NEMESIS model, built for EU-27 countries only, is not suited to deal with world carbon markets and clean development mechanisms implied by the 30 % reduction target;
2. NEMESIS cannot impose emissions constraints on GHG emissions other than CO_2. This does not change anything for EU ETS sector where the emissions reduction objective concerns CO_2 only. For non EU ETS sector on the contrary, this imposed to put all the reduction effort on CO_2 only (to reach the overall 20 % reduction for GHG in CO_2 equivalent), leading for greater reductions for CO_2 emissions, and lower reductions for other GHG, than in other assessments;
3. CCS directive could not be taken into account also, and this could lead to the calculation of greater values for carbon price than in other assessments;
4. No re-investments where imposed of 20 % of auctioning revenues in strategic sectors for energy savings and climate change. This was replaced in one scenario by a subsidy to firms' R&D that increases productivity and consequently decreases energy intensity of productive sectors and consumption goods.

The other aspects of the implementation protocol in NEMESIS conform globally the lines of the 'climate Action and Renewable Energy Package' that are detailed below in four points:

1. the setting of emissions constraint in EU ETS and non EU ETS sectors;
2. the sharing of renewable energies objective between member states;
3. calculation of auctioning revenue by member states;
4. the recycling of auctioning revenue which leads to distinguish three different scenarios

1.2.1- The setting of emissions constraint in EU ETS and non EU ETS sectors

EU ETS sectors

The third phase of EU ETS that will begin in 2013 include sectors not covered by phase 2 system. It the NEMESIS nomenclature, it concerns 10 distinct production sectors (see table 1) regrouping energy intensive industries and air transports, that the third phases adds together with chemical industry.

Table 1: NEMESIS participation to EU ETS

04 - Gas-Distribution
05 - Refined-Oil
06 – Electricity
08 - Ferrous&NonFerrous-Metals
09 - Non Metalic-Mineral-Production
10 – Chemicals
11 - Metal-Products
18 - Paper&Printing-Production
19 - Rubber&Plastic
25 - Sea&Air-Transport

Compared to 2005, the 'EU ETS review' fixes a CO_2 linear reduction objective of 1.74 % per year from 2013 to 2020 with a target for 2013 that will be based on the average emission level of the period 2008-2012. In terms of GHG emissions, a reduction of -18.2 % is expected, compared to 2005 levels. The CO_2 emission constraint for ETS sectors is identical for all EU member states. In every countries, the quantity of allowances distributed per sector is set in NEMESIS following the grandfathering principle, that is to say proportionally to the contribution of the sector to EU ETS CO_2 average emissions for the period 2008-2012. There is free trade of CO_2 quotas between countries and sectors. Finally, to conform again the lines of 'EU ETS review' proposal, allowances are attributed by full auctioning from 2013 in power sector. For other sectors, 80 % of allowances are attributed freely in 2013 and 80 % by auctioning. The share of auctioning increases linearly and reaches 100 % in 2020.

Non EU ETS sectors

For non EU ETS sectors, GHG emissions reduction target are fixed following verified emissions levels in 2005, with a sharing of emission reduction effort amongst member states based on the principles of growth, fairness and solidarity, and assuring to reach the EU's 20 % emission reduction commitments.

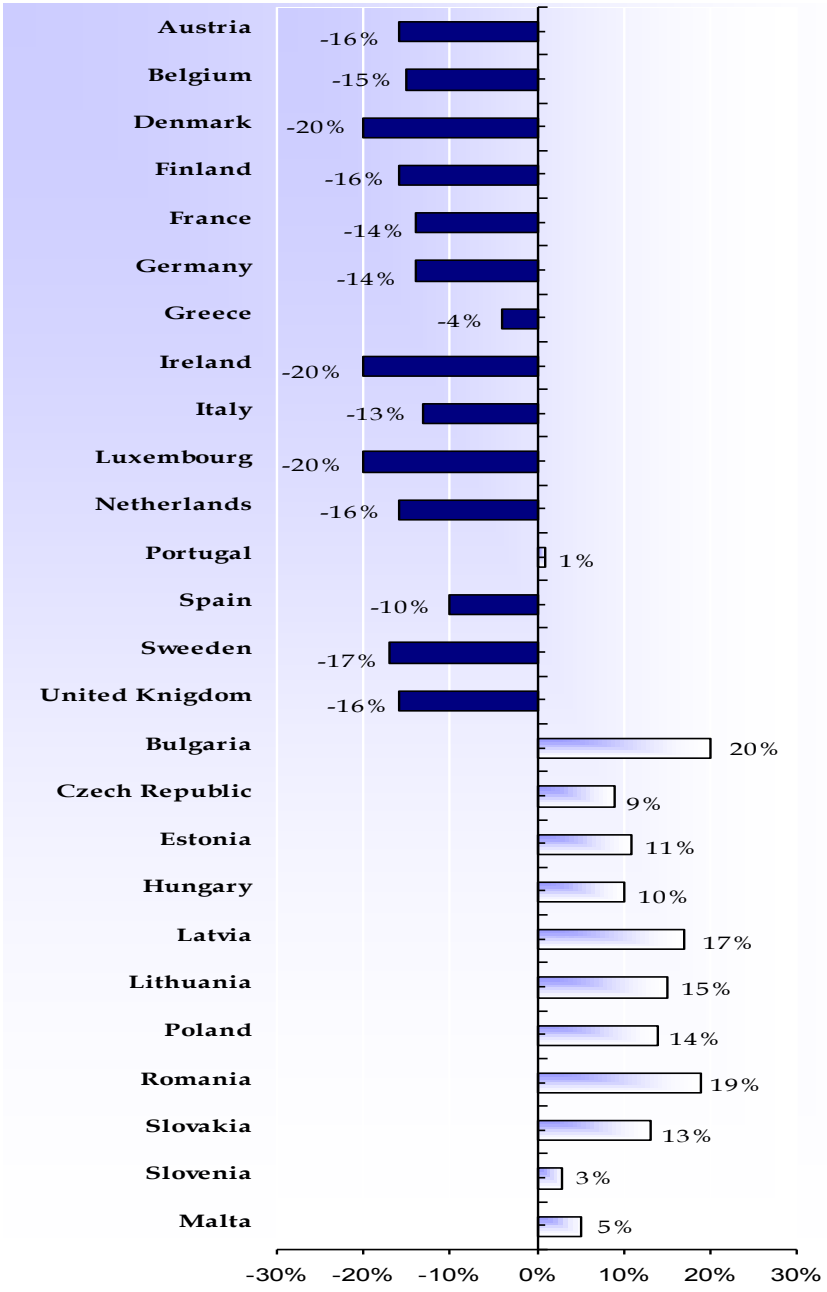
In terms of NEMESIS nomenclature, non EU ETS covers 20 production sectors, displayed in table 2 and includes also GHG emissions by households.

Table 2: NEMESIS non EU ETS sectors

01 – Agriculture
02 - Coal&Coke
03 - Oil&Gas-Extrac
07 - Water-Supply
12 - Agric&Industr-Machines
13 - Office-Machines
14 - Electrical-Goods
15 - Transport-Equipment
16 - Food-Drink&Tobacco
17 - Textile-Clothes&Footwear
20 - Other-Manufactures
21 – Construction
22 – Distribution
23 - Lodging&Catering
24 - Inland-Transports
26 - Other-Transport,
27 – Communication
28 - Bank-Finance&Insurance
29 - Other-Market-Services
30 - Non-Market-Services

In NEMESIS, national targets are reached by imposing in each country GHG emissions caps that are lowered linearly from 2013 to 2020. Emissions caps are imposed by introducing in each country an endogenous tax on non-EU-ETS CO_2 emissions, identical for all production sectors and households. This carbon taxation is integrally redistributes to firms and households by equivalent subsidies to production and increases in disposable income. In this way, carbon taxation provokes substitutions effects (between energy products and energy and other products and production factors) necessary to reach the target, but no revenue effects. It is in this sense fiscally neutral, and this was the best option in the absence of precise information onto the preferred actions for limiting GHG emissions in the different countries

Figure 3: Reduction targets per country for non EU-ETS sectors in 2020 compared to 2005



GHG emissions target goes from -20 % in richer member states as Denmark to +20 % in poorest countries as Bulgaria.

1.2.2- The sharing of renewable energies objective between member states

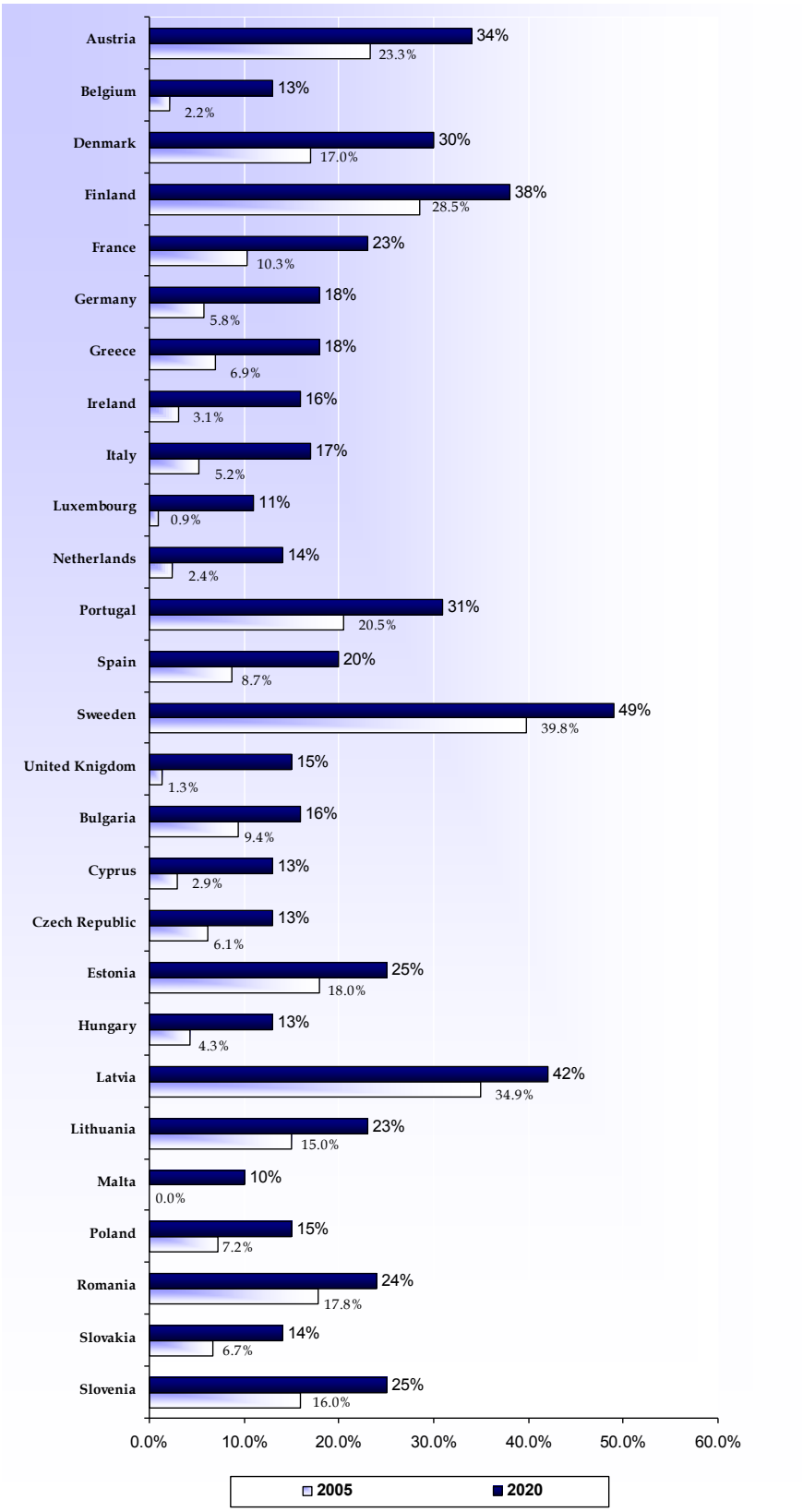
For renewable energies objective of 20 % share in final energy consumption for EU-27, no specific targets were set by Member State and consequently no specific policies as subsidies for the adoption of renewables, in addition from policies already in place and accounted for in the baseline scenario. As it will be discussed below in the section that present NEMESIS/NOMEDE baseline scenario, the high oil and gas price context that taken place in recent years allow increasing economic competitiveness of renewable energy sources, such as win in power generation and biofuels in transport sector.

The scenarios studied for assessing for the EU 'Climate Action and Renewable Energy Package' shown furthermore that the 20 % renewable target could be spontaneously reached, or approached closely, at horizon 2020, as a consequence of the important rise in carbon price necessary for reaching EU post-Kyoto objectives. It is true equally at country level, many EU Member States being able come close their renewable potential, illustrated by figure 4.

For biofuels share in transports gasoline and diesel, the 10 % objective is also reached spontaneously as a consequence of baseline assumptions and scenarios evolutions, and no specific policies were then considered.

For both renewables and biofuels share objective, baseline evolutions by country were adapted from PRIMES projections ("Energy and Transport: Trends to 2030 – Update 2007", European Commission/ Directorate-General for Energy and Transport.), with differences resulting principally from the use of different oil reference price in PRIMES and NEMESIS baseline projections.

Figure 4: EU-27 countries potential for renewable energies, as % of final energy consumption

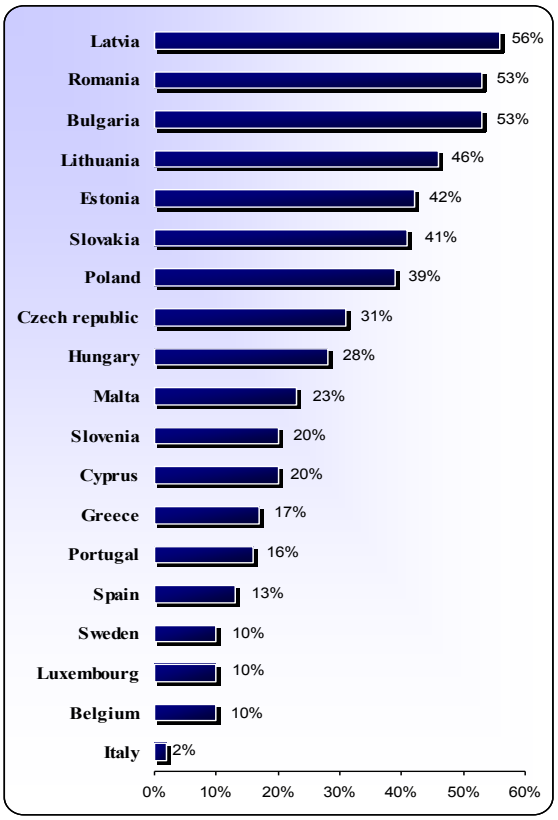


Source: European Commission, Directive of the parliament and of the council on the promotion of the use of energy from renewable sources, com (2008) 30 final.

1.2.3- Calculation of auctioning revenue by Member States

In the scenarios considered with NEMESIS, there is no revenue generation, and consequently no revenue recycling from non EU ETS sectors GHG emissions taxation. For ETS sectors on the contrary, as quoted in section 1.2.2, CO_2 quotas generate revenue from auctioning, that increase gradually between 2013 and 2020 with the yearly diminution of emissions caps and the increasing share of CO_2 to be auctioned.

Figure 5: Percentage of increase in allowances to be auctioned for the purpose of community solidarity



Source: European Commission (Proposal Directive to Improve and extend the Greenhouse Gas Emission Allowance Trading System COM(2008))

Auctioning revenue in each Member state takes furthermore into account the fact that 10 % of auctioning revenue should be used for the purpose of community solidarity. More precisely, 90 % of auctioning rights are distributes accordingly to Member States share in 2005 emissions in the EU ETS, and the remaining 10 % are redistributed to low income countries, taking into account their GDP per capita and their overall growth expectations.

This distribution of auctioning rights results in significant reduction of overall direct costs experienced by member states with a low GDP per capita, with limited direct costs increases for richer countries. Revenues generated by auctioning are actually substantial. They can reach, depending the scenario studied, about 0.8 % European GDP in 2020, and they can exceed 1.5 % GDP in countries as Romania, Slovakia and Poland that beneficiate the more from the solidarity principle. Thus, some member states, especially in new accessing countries, receive and redistribute more than their auctioning quotas, as resumed on figure 5.

1.2.4- Recycling of auctioning revenue: three different scenarios

Three distinct scenarios are considered, that differ from the use of EU ETS auctioning revenue by Member States:

- in scenario S1, auctioning revenue is kept by States and used for decreasing national debt. There is no recycling through public investment or revenue redistribution to private agents;
- in scenario S2, revenue of auctioning in EU ETS sector is recycled through an equivalent reduction, in terms of amount, of employers' social contribution rate;
- in scenario S3, auctioning revenue is recycled in two ways: A reduction, as in scenario S2, of employers' social contributions rate, and a general subsidy to private R&D expenditures up to 30 %. The R&D subsidy in calculated first, and only the difference between auctioning revenue and R&D subsidies is used to reduce employers' social contribution rate.

Results for scenario S1 will thus allow assessing for direct impacts of increasing carbon price, while results for scenarios S2 and S3 will indicate the extent to which the economic costs of EU post-Kyoto can be alleviate, or even fully compensated, by a transferring fiscal weight from labor and R&D to carbon and other GHG.

2- Baseline evolutions for energy and environment indicators

For the baseline scenario, it is assumed that only policies already in place in 2007 are active and that current ETS system continues to operate, with a low price for carbon that rises from 20 constant € 2005 /ton CO_2 equivalent in 2008 up to 23 constant € 2005 euros in 2020.

The baseline evolutions differ slightly to account for the most recent trends onto energy prices (see figure 6). The high oil prices observed on the past two years are supposed to persist but with a slow decrease from 107 € in 2008 to 68 € 2015, and then progressive re-augmentation until 76 € in 2020. Oil price is derived from PROMETHEUS projections (NTUA). It accounts for continuous resource constraint, rapid growth of world oil demand and high extraction costs. Gas prices were indexed on oil price while coal price was supposed to grow at lower rates in reason of high coal resources level.

These high oil and energy prices have a negative impact on GDP growth rate in EU-27, that establish to 2.34 % in annual average growth rate for the period 2005-2020. GDP growth rate stays high, thanks notably to high exports toward countries outside Europe.

GDP growth stays higher for new Member States, with an increase of 78 % on the period 2005-2020 against only 37 % for Eu-15 countries, and 37 % for EU-27.

Figure 6: Evolution of oil price in constant € 2005

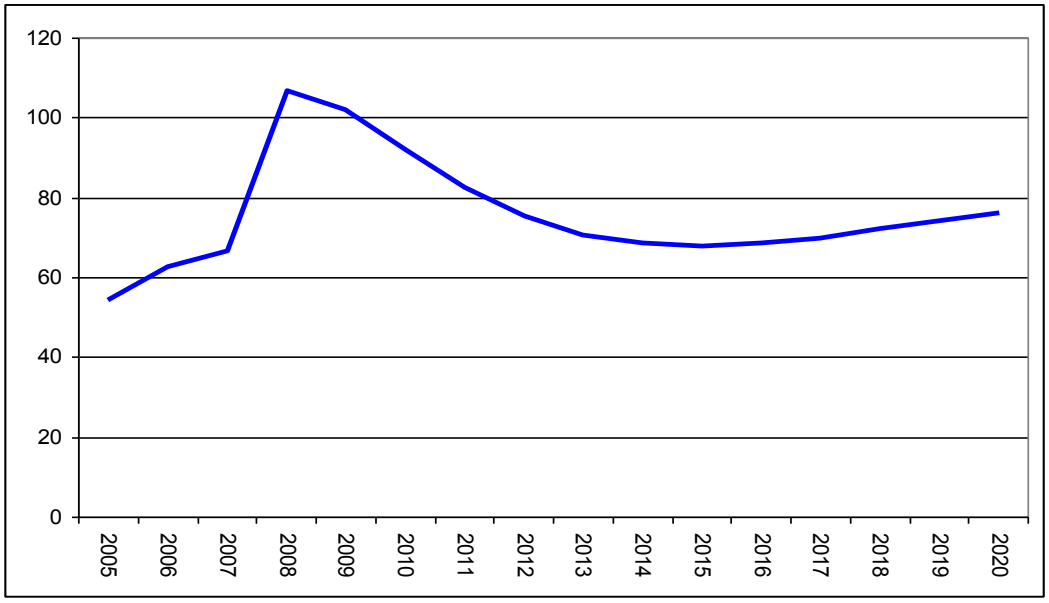


Table 3: Evolution of GDP in EU-27 countries between 2005 and 2020, baseline scenario

	2005	2010	2015	2020	2005-10	2010-15	2015-20	2005-20
					Annual % Change			
Austria	100	108	122	134	1.64	2.30	2.05	2.00
Belgium	100	105	119	133	0.93	2.55	2.26	1.91
Denmark	100	106	125	130	1.19	3.34	0.84	1.78
Germany	100	105	116	128	0.91	2.16	1.90	1.65
Finland	100	115	136	156	2.87	3.32	2.78	2.99
France	100	107	121	137	1.34	2.58	2.42	2.11
Greece	100	112	136	158	2.38	3.85	3.02	3.08
Irland	100	121	149	176	3.85	4.27	3.42	3.85
Italy	100	101	112	124	0.22	2.13	1.97	1.44
Luxembourg	100	121	147	174	3.88	3.94	3.50	3.78
Netherlands	100	110	127	144	1.85	3.07	2.45	2.45
Portugal	100	101	113	128	0.17	2.21	2.65	1.67
Spain	100	113	134	154	2.46	3.46	2.86	2.93
Sweeden	100	114	138	160	2.71	3.84	3.06	3.20
United Kingdom	100	111	128	144	2.03	3.04	2.36	2.47
Czech Republic	100	124	151	181	4.37	4.04	3.69	4.03
Estonia	100	150	223	290	8.50	8.17	5.40	7.35
Latvia	100	141	197	250	7.15	6.93	4.86	6.31
Lithuania	100	130	172	211	5.40	5.72	4.20	5.11
Hungary	100	111	134	157	2.08	3.83	3.23	3.04
Malta	100	111	130	153	2.07	3.29	3.31	2.89
Poland	100	116	143	172	3.09	4.25	3.70	3.68
Slovenia	100	121	150	179	3.84	4.41	3.65	3.97
Slovakia	100	126	157	193	4.71	4.57	4.12	4.47
Romania	100	117	152	185	3.14	5.48	3.96	4.19
EU-15	100	107	122	137	1.40	2.69	2.28	2.12
EU-12	100	119	148	178	3.52	4.48	3.77	3.92
EU27	100	108	123	139	1.46	2.80	2.33	2.20

Source: NEMESIS model

At sectoral level, production growth in EU-27 stays strong in EU-ETS sectors, with an increase of 42 % between 2005 and 2020, due notably to the dynamism of chemical and air transports industries. Non EU ETS sectors grow about 35 % on the same period.

Table 4: Production growth in EU ETS and non EU ETS sectors, baseline scenario

	2005	2010	2015	2020	2005-10	2010-15	2015-20	2005-20
					Annual % Change			
Agriculture	100	99	101	103	-0.12	0.26	0.47	0.20
Industry	100	109	121	137	1.74	2.17	2.43	2.11
- energy Intensive industries	100	110	123	140	1.86	2.36	2.66	2.29
- other industries	100	109	120	135	1.67	2.06	2.30	2.01
Construction	100	109	121	139	1.66	2.27	2.72	2.22
Tertiary	100	108	120	136	1.56	2.18	2.51	2.08
Transport	100	111	126	146	2.08	2.66	2.89	2.54
- see & air	100	114	134	156	2.64	3.22	3.21	3.02
- road & rail	100	109	123	140	1.80	2.35	2.72	2.29
EU-ETS sectors	100	110	124	142	1.94	2.45	2.72	2.37
Non EU-ETS sectors	100	108	120	135	1.56	2.12	2.45	2.04

For energy demand, the baseline evolutions show the continuation of energy efficiency improvement already observed in the past period. Final energy consumption increases 20 % in EU-27 over the period 2005-2020 (table 5) against 39 % for GDP.

Table 5: Final energy demand in EU-27, baseline scenario

	2005	2010	2015	2020	2005-10	2010-15	2015-20	2005-20
in toe		Index			Share in Total			
Agriculture	100	107	118	129	0.03	0.03	0.03	0.03
Energy branch	100	97	101	106	0.07	0.07	0.07	0.07
Industry	100	101	106	112	0.25	0.24	0.24	0.23
- energy Intensive industries	100	99	103	107	0.18	0.18	0.17	0.16
- other industries	100	105	114	123	0.07	0.07	0.07	0.07
Residential	100	105	116	128	0.16	0.17	0.17	0.17
Tertiary	100	104	113	122	0.11	0.11	0.11	0.11
Transport	100	103	113	124	0.38	0.38	0.39	0.39
- see & air	100	109	128	147	0.04	0.05	0.05	0.05
- road & rail	100	102	111	121	0.34	0.34	0.34	0.34
EU-ETS sectors	100	100	106	113	0.29	0.28	0.28	0.27
Non EU-ETS sectors	100	104	113	123	0.70	0.71	0.71	0.72
Total	100	103	111	120	1.00	1.00	1.00	1.00

Source: NEMESIS model

Gains in energy efficiency come partly from exogenous assumptions for fuel efficiency in passengers and freight transport and in thermal electricity production, that were taken from PRIMES model[7], that was used to assess for the EU 'Climate Action and Renewable Energy Package'[8]. Energy efficiency gains results also from the high oil and gas prices that combined with the carbon value in EU ETS sector lead to high-energy prices, and from continued de-materialization of industrial production and the development of services in European economies.

Table 6: Primary energy demand by product in EU-27, baseline scenario

	2005	2010	2015	2020	2005-10	2010-15	2015-20	2005-20
in toe		Index			Share in Total			
Solids	100	96	96	97	0.16	0.15	0.14	0.13
Oil	100	98	106	113	0.35	0.34	0.34	0.34
Gas	100	103	113	122	0.27	0.27	0.28	0.28
Electricity	100	105	115	126	0.17	0.18	0.18	0.18
Other	100	132	152	181	0.04	0.06	0.06	0.07
Total	100	102	110	118	1.00	1.00	1.00	1.00

Source: NEMESIS model

[7] "Energy and Transport: Trends to 2030 – Update 2007", European Commission/ Directorate-General for Energy and Transport.

[8] The package consists of legislative proposals including three actions: a) Amendment of Directive 2003/87/EC so as to improve and extend the EU greenhouse gas emission allowance trading system; b) Decision on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020; c) Directive on the promotion of use of renewable energy sources.

Despite high oil prices, the demand for petroleum products is expected to stay at a high level during the period 2005-2020, with a rise of 13 % of oil demand that concentrates for specific use: Transports and petrochemical. The demand for gas rises 22 % over the period, while the demand for solids (coal and lignite) reduces 3 %. The evolution for gas is mainly attributable to the massive substitution of gas to coal and oil in power generation (see table 7). Electricity takes a share in primary energy demand, with a demand that increases 26 % over the period, an evolution supported by the development of renewable in power sector, which gain economic competitiveness over the period. Other energy sources, mainly biomass, play also an increasing role, with a demand growing about 4 % per year over 2005-2020.

Table 7: Fuels inputs in thermal power generation in EU-27, baseline scenario

	2005	2010	2015	2020	2005-10	2010-15	2015-20	2005-20
in toe		Index			Share in Total			
Solids	100	97	98	99	0.55	0.53	0.51	0.49
Oil	100	77	71	60	0.09	0.07	0.06	0.05
Natural Gas	100	108	121	135	0.30	0.32	0.35	0.37
Biomass and Waste	100	132	154	185	0.06	0.08	0.09	0.10
Total	100	101	106	112	1.00	1.00	1.00	1.00

Source: NEMESIS model

Table 7 illustrates the rising importance of biomass for the power sector, which demand increases 85 % on 2005-2020. The use of solids in power sector stabilizes around its 2005 level, and benefits from the gradual diminution of nuclear contribution in base load, resulting from the assumptions mad in baseline. Assumptions for nuclear follow PRIMES[9] projections, as well as projection for hydro-electricity, that grow 9 % (table 8) over 2005-2020 period, and for geothermal electricity that grow 35 %, but with a potential that stay limited.

Table 8: Main energy system indicators for EU-27, baseline scenario

	2005	2010	2015	2020	2005-10	2010-15	2015-20	2005-20
in toe					Annual % Change			
Gross inl. Consumption/Capita (100 in 2005)	100	101	106	115	0.18	1.06	1.57	0.93
Gross inl. Consumption/GDP (100 in 2005)	100	95	90	87	-1.02	-1.03	-0.82	-0.96
Electricity generation	100	105	114	127	0.94	1.76	2.19	1.63
- Nuclear	100	92	96	104	-1.55	0.74	1.61	0.26
- Hydro	100	99	102	109	-0.21	0.68	1.24	0.57
- Wind	100	273	556	1023	22.22	15.33	12.95	16.77
- Solar	100	221	428	761	17.21	14.13	12.19	14.49
- Geothermal	100	99	113	135	-0.22	2.77	3.63	2.05
- Thermal	100	106	116	129	1.18	1.84	2.08	1.70

Source: NEMESIS model

Table 8 shows finally the increasing importance of wind and nuclear for electricity generation, these energy sources growing respectively 17 % and 15 % per year over the 2005-2020 period. The expansion of electric sector in baseline scenario, results then from the development of specific electricity uses and a demand rising 1.6 % per year in average, and from massive investments in combined cycle gas, biomass based power, wind and to a lesser extent solar.

[9] "Energy and Transport: Trends to 2030 – Update 2007", European Commission/ Directorate-General for Energy and Transport.

Table 9: GHG emissions by sector in EU-27, baseline scenario

European

	2005	2010	2015	2020	2005-10	2010-15	2015-20	2005-20
in CO_2 units		Index				Share in Total		
Power Generation	100	92	89	86	0.29	0.27	0.26	0.24
Energy Branch	100	97	103	109	0.06	0.06	0.06	0.06
Agriculture	100	100	103	106	0.13	0.13	0.13	0.13
Industry	100	101	108	115	0.14	0.14	0.15	0.15
- energy Intensive industries	100	100	107	113	0.10	0.11	0.11	0.11
- other industries	100	104	113	121	0.03	0.03	0.04	0.04
Residential	100	102	112	121	0.09	0.09	0.10	0.10
Tertiary	100	103	111	119	0.04	0.05	0.05	0.05
Transport	100	96	101	106	0.26	0.26	0.26	0.27
- see & air	100	108	126	143	0.03	0.04	0.04	0.05
- road & rail	100	94	97	100	0.22	0.22	0.22	0.22
EU-ETS sectors	100	95	97	99	0.47	0.47	0.46	0.45
Non EU-ETS sectors	100	98	103	108	0.51	0.52	0.53	0.53
Total	100	97	100	103	1.00	1.00	1.00	1.00

Source: NEMESIS model

These energy and economic trends of the baseline scenario result in a moderate increase of GHG emissions over the period 2005-2020 in EU-27 countries (see table 9).

From 2005 to 2010, GHG emissions first decrease, in a context of very high oil and gas prices. Emissions decrease 8 % in the power sector, where the decrease results from using more gas and oil and solids, and more renewable. The stabilization of emissions in other energy intensive industries in this first period of low economic growth, allow GHG emissions to reduce 5 % in the EU ETS sector. For non EU ETS sector, emissions reduce 2 % in 2010 compared to 2005, from the reductions realized inside the energy branch. In 2010, GHG emissions are 3 % lower their 2005 level in EU-27, that is to say 14.3 % their 1990 level. This is below the Kyoto objective of 8 % emissions reduction for 2010-2012 period compared to 1990.

For the period 2010-2020, the economic growth that was hampered by the very high oil and gas price of the first period recovers. Energy prices stay high and favorable to the development of renewable energy sources, but the important rise in energy demand (16 % between 2010 and 2020 against only 2 % between 2005 and 2010) does not allow stabilizing the level of CO_2 and of other GHG emissions. GHG emissions re-augment 3 % between 2010 and 2015 and again 3 % between 2015 and 2020, to establish 3 % above their 2005 level, and 7.7 % below their 1990 level. Compared to 2005 level, emissions are stabilized in EU ETS sector, where the 23 € 2005 /ton CO_2 carbon value allow satisfying EU-27 Kyoto objective. For non EU ETS

Table 10: Green house gases emissions per EU-27 country, baseline scenario

	2010	2015	2020	2010	2015	2020	2010	2015	2020
100 in 2005	CO_2			Other GHG emissions			Total GHG emissions		
Austria	97	100	104	103	109	116	98	102	106
Belgium	97	102	108	101	106	114	98	103	108
Denmark	90	91	84	102	112	113	92	94	89
Germany	93	91	89	101	106	111	94	93	92
Finland	93	91	90	105	112	120	94	94	94
France	96	100	104	101	106	112	98	101	106
Greece	96	98	98	105	116	128	98	101	104
Irland	102	105	109	100	101	104	101	104	107
Italy	93	99	106	98	105	113	94	100	107
Luxembourg	103	105	111	110	121	135	103	106	112
Netherlands	99	106	111	105	115	125	100	107	113
Portugal	94	98	105	95	98	103	94	98	104
Spain	94	98	102	103	114	124	96	101	106
Sweeden	98	105	117	103	110	117	99	106	117
United Kingdom	98	98	97	104	111	117	99	100	100
Czech Republic	93	91	91	104	109	116	95	94	95
Estonia	96	97	97	104	109	115	97	99	99
Latvia	114	131	149	111	121	132	113	129	144
Lithuania	111	124	135	113	137	160	112	129	143
Hungary	99	104	112	104	111	121	100	105	114
Malta	98	99	100	109	124	143	99	99	100
Poland	95	95	97	105	111	119	97	98	100
Slovenia	99	102	107	108	119	132	102	107	114
Slovakia	107	118	131	107	117	130	107	117	130
Romania	107	123	141	109	123	139	108	123	141
EU-15	95	97	99	102	108	115	96	99	102
EU-12	98	102	107	106	115	126	100	104	111
EU27	96	98	100	103	110	117	97	100	103

Source: NEMESIS model

GHG emissions show contrasted evolutions at member States level (table 10). For CO_2, (only energy related emissions are measured) the global stabilization at EU-27 level over the period 2005-2020 dissimulates a 7 % increase in new member State, while emissions are reduced about 1 % in EU-15 countries were economic growth rate is 46 % inferior to the one of new member States. For other GHG, we have a stabilization of CH4 emissions form agriculture, but an increase notably from waste production, gas production and transportation. They increase globally 9 % between 2005 and 2020. The strongest emissions increases are HFC (49 %), PFC (46 %) and SF6 (39 %). For N2O, emissions are projected to increase 18 %. Globally, non CO2 GHG emissions increase 17 % over the 2005-2020 period, with also a higher increase in new member states, with +26 % against +15 % in EU-15 countries.

Table 11: Main environmental indicators for EU-27 countries, baseline scenario

	2005	2010	2015	2020	2005-10	2010-15	2015-20	2005-20
in toe					Annual % Change			
CO2 emissions/Capita	100	95	96	98	-0.93	0.03	0.57	-0.12
CO2 emissions to GDP	100	90	81	74	-2.12	-2.03	-1.80	-1.99
Carbon intensity (CO_2 on gross energy inl. consumption)	100	95	90	85	-1.12	-1.02	-0.99	-1.04
Share of renewables in power generation (%)	0.16	0.18	0.21	0.26	2.89	3.16	3.83	3.29
Share of renewables in final energy consumption (%)	0.10	0.10	0.11	0.13	0.49	2.12	2.25	1.62
Biofuels share in transport gasoline and diesel (%)	0.00	0.03	0.04	0.06	42.48	10.15	6.56	18.70

Source: NEMESIS model

The baseline evolutions for GHG emissions over the 2005-2020 period reveal moderate increases despite the relatively high economic growth and rise in energy demand foreseen in this scenario. This is traduced in table 11 for CO_2 by a decrease of 2 % of emissions in EU-27 between 2005 and 2020, of 26 % of emissions per constant k-euros GDP and of 15 % of energy carbon intensity. Emissions intensity reduction of GDP in then the result of both increased decoupling of energy consumption from GDP growth, and from high energy prices that strengthen energy substitutions away from fossil fuel

and carbon intensive energies. This last phenomena pass notably through the development of renewable energy forms, which share increases 10 % in power generation on the period, from 16 % in 2005 to 26 % in 2025, and from respectively 9.5 % to 13 % in final energy consumption, while the share of biofuels in transport gasoline and diesel increase from about 0.5 % in 2005 to nearly 6 % in 2020.

Table 12: Share of renewables in final energy consumption by country, baseline scenario

	2005	2010	2015	2020	2005-10	2010-15	2015-20	2005-20
in % (1 = 100%)					Annual % Change			
Austria	0.24	0.25	0.26	0.26	0.52	0.46	0.04	0.34
Belgium	0.05	0.06	0.07	0.07	1.44	2.47	2.19	2.03
Denmark	0.16	0.19	0.22	0.26	3.05	3.73	3.33	3.37
Germany	0.08	0.10	0.13	0.15	4.38	4.60	4.04	4.34
Finland	0.27	0.28	0.29	0.30	1.25	0.39	0.74	0.79
France	0.11	0.12	0.12	0.12	1.52	0.31	0.89	0.90
Greece	0.07	0.08	0.09	0.10	3.27	2.34	2.65	2.75
Irland	0.03	0.04	0.05	0.07	3.34	6.41	5.87	5.20
Italy	0.08	0.09	0.10	0.11	2.02	2.18	1.94	2.04
Luxembourg	0.02	0.03	0.04	0.05	6.90	8.80	5.11	6.92
Netherlands	0.04	0.04	0.05	0.06	1.54	2.85	3.82	2.73
Portugal	0.19	0.21	0.21	0.21	1.32	0.51	0.13	0.65
Spain	0.09	0.10	0.12	0.13	3.63	2.10	2.79	2.84
Sweeden	0.33	0.34	0.34	0.34	0.27	-0.03	-0.04	0.07
United Kingdom	0.03	0.04	0.05	0.06	4.64	5.51	5.88	5.34
Czech Republic	0.06	0.08	0.09	0.09	4.97	2.25	1.53	2.90
Estonia	0.20	0.20	0.19	0.19	-0.31	-1.53	0.20	-0.55
Latvia	0.37	0.36	0.35	0.34	-0.45	-0.76	-0.12	-0.44
Lithuania	0.16	0.16	0.16	0.18	-0.07	0.98	1.60	0.83
Hungary	0.06	0.06	0.07	0.07	0.78	1.22	0.24	0.74
Malta	0.00	0.01	0.01	0.04	30.34	19.51	25.65	25.09
Poland	0.09	0.09	0.11	0.12	2.02	2.77	2.60	2.46
Slovenia	0.16	0.16	0.16	0.16	0.24	0.31	-0.05	0.17
Slovakia	0.06	0.06	0.06	0.06	-0.49	0.61	1.30	0.47
Romania	0.17	0.18	0.17	0.17	0.30	-0.51	-0.79	-0.33
EU27	0.09	0.10	0.11	0.13	2.24	2.12	2.25	2.20

Source: NEMESIS model

The increase of renewables in final energy consumption (table 12) is particularly the fact of big countries as Germany (from 8 % to 15 %), Italy (from 8 % to 11 %) Spain (from 9 % to 13 %) and United Kingdom (from 3 % to 6 %), where the initial share or renewable is initially low, but there is increased in every countries with the exceptions of Estonia (24 % to .19 %), Latvia (37 % to 34 %) and Slovenia (16 %), Slovakia (6 %) and Romania (17 %) where it is stable.

Country evolutions are more contrasted for renewables share in power generation sector (Table 13) with huge increases in countries as Germany, Denmark, Spain and Latvia, and stabilization or slight decreases in other countries, as Austria, France, Italy, Luxembourg, Sweden in EU-15 and Estonia, Hungary, Malta, Slovenia, Slovakia and Romania in new member States.

Table 13: Share of renewables in power generation sector in EU-27, baseline scenario

	2005	2010	2015	2020	2005-10	2010-15	2015-20	2005-20
	in % (1 = 100%)				Annual % Change			
Austria	0.71	0.69	0.68	0.68	-0.39	-0.30	-0.09	-0.26
Belgium	0.03	0.03	0.03	0.04	4.46	1.88	4.35	3.56
Denmark	0.25	0.34	0.41	0.53	6.74	3.89	5.01	5.21
Germany	0.11	0.19	0.30	0.45	12.81	9.51	8.16	10.15
Finland	0.35	0.39	0.42	0.45	2.46	1.62	1.25	1.78
France	0.14	0.14	0.14	0.15	-0.25	0.25	1.37	0.45
Greece	0.10	0.12	0.15	0.19	3.72	4.57	5.60	4.63
Irland	0.05	0.07	0.09	0.14	4.03	6.82	8.78	6.53
Italy	0.19	0.18	0.18	0.18	-0.35	-0.32	-0.11	-0.26
Luxembourg	0.13	0.13	0.13	0.14	0.58	0.40	0.68	0.55
Netherlands	0.07	0.08	0.09	0.10	3.65	1.76	3.40	2.93
Portugal	0.30	0.29	0.30	0.32	-0.17	0.40	1.29	0.50
Spain	0.21	0.26	0.34	0.47	4.35	5.50	6.69	5.51
Sweeden	0.56	0.55	0.53	0.53	-0.34	-0.56	-0.32	-0.41
United Kingdom	0.03	0.05	0.06	0.09	6.59	6.18	8.33	7.03
Czech Republic	0.04	0.05	0.06	0.06	5.08	2.15	1.07	2.75
Estonia	0.00	0.01	0.01	0.01	14.17	5.44	4.22	7.85
Latvia	0.72	0.80	0.85	0.89	2.22	1.22	0.92	1.45
Lithuania	0.07	0.12	0.18	0.26	10.29	8.42	7.42	8.71
Hungary	0.01	0.01	0.02	0.02	3.97	3.53	3.92	3.80
Malta	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Poland	0.02	0.03	0.04	0.07	7.15	8.75	11.28	9.05
Slovenia	0.28	0.27	0.26	0.26	-0.59	-0.65	-0.54	-0.59
Slovakia	0.16	0.15	0.14	0.13	-0.97	-1.54	-1.54	-1.35
Romania	0.28	0.28	0.27	0.28	-0.46	-0.29	0.35	-0.13
EU27	0.16	0.18	0.21	0.26	2.89	3.16	3.83	3.29

Table 14: Share of biofuels in transport gasoline and diesel

	2005	2010	2015	2020	2005-10	2010-15	2015-20	2005-20
in % (1 = 100%)					Annual % Change			
Austria	0.00	0.03	0.04	0.06	42.48	10.15	6.56	18.70
Belgium	0.00	0.01	0.03	0.05	752.61	19.21	9.44	123.22
Denmark	0.00	0.03	0.05	0.07	745.89	13.24	8.40	118.16
Germany	0.02	0.04	0.05	0.06	14.08	5.66	2.91	7.45
Finland	0.00	0.01	0.03	0.05	613.51	19.77	7.10	109.18
France	0.01	0.03	0.04	0.05	28.62	9.80	4.82	13.97
Greece	0.00	0.02	0.03	0.05	769.54	13.34	6.28	118.80
Irland	0.00	0.02	0.04	0.05	150.34	15.25	8.07	46.09
Italy	0.00	0.03	0.04	0.06	56.79	9.45	7.05	22.47
Luxembourg	0.00	0.02	0.05	0.07	119.06	18.69	8.05	41.10
Netherlands	0.00	0.02	0.05	0.07	880.09	19.12	9.27	133.66
Portugal	0.00	0.02	0.04	0.05	769.95	14.36	7.81	120.53
Spain	0.01	0.04	0.07	0.09	43.46	12.11	3.24	18.42
Sweeden	0.02	0.04	0.05	0.07	11.29	7.91	4.67	7.92
United Kingdom	0.00	0.02	0.04	0.06	67.71	14.56	8.25	27.64
Czech Republic	0.00	0.05	0.07	0.09	147.39	8.70	4.91	41.30
Estonia	0.00	0.04	0.06	0.07	565.85	8.57	3.81	95.79
Latvia	0.00	0.03	0.05	0.08	64.68	9.97	8.01	25.06
Lithuania	0.00	0.01	0.02	0.06	29.09	26.14	19.02	24.68
Hungary	0.00	0.04	0.06	0.08	760.80	9.25	6.23	115.37
Malta	0.00	0.00	0.01	0.02	0.00	0.00	0.00	0.00
Poland	0.00	0.03	0.06	0.09	44.29	13.84	8.98	21.42
Slovenia	0.00	0.01	0.04	0.05	382.29	19.51	9.04	84.54
Slovakia	0.01	0.03	0.06	0.09	30.18	16.25	9.97	18.50
Romania	0.00	0.01	0.02	0.03	593.54	14.73	5.15	103.01
EU27	0.00	0.03	0.04	0.06	42.48	10.15	6.56	18.70

Source: Modèle NEMESIS

Baseline scenario evolutions for biofuels in transports gasoline and diesel share show on contrary quite homogenous evolutions across EU countries (table 14), from levels inferiors to 0.5 % in 2005 to 5 to 9 % in 2020 for most countries. This can be explained by the fact that biofuels penetration is more directly linked to oil price and other market

considerations, than other renewables which penetration depend heavily on country specific potentials, and historic characteristics of energy supply and demand system.

3- Scenarios results

Figure 7 resumes the GHG emissions reduction effort to be achieves in EU-27 in order to reach the EU post-Kyoto objective of 20 % emissions reductions compared to 1990 level. One can see on this table that at European scale baseline evolutions over 2005-2020 period implies a reduction of 13.7 % of GHG emissions to reach EU post-Kyoto objectives (from index 92.7 to 80), whereas situation of European countries toward post-Kyoto objective are very contrasted.

In EU-15 countries, emissions level in 2020 should be identical to 1990 level from NEMESIS baseline projections, with very high increases of emissions levels in southern countries as Spain (62 % increase compared to 1990) and Portugal (47 % increase). On the other hand, countries as Germany, that is 25 % below 1990 level in 2020, and also Denmark and united Kingdom, respectively 18 and 16 % their 1990 level show very virtuous evolutions.

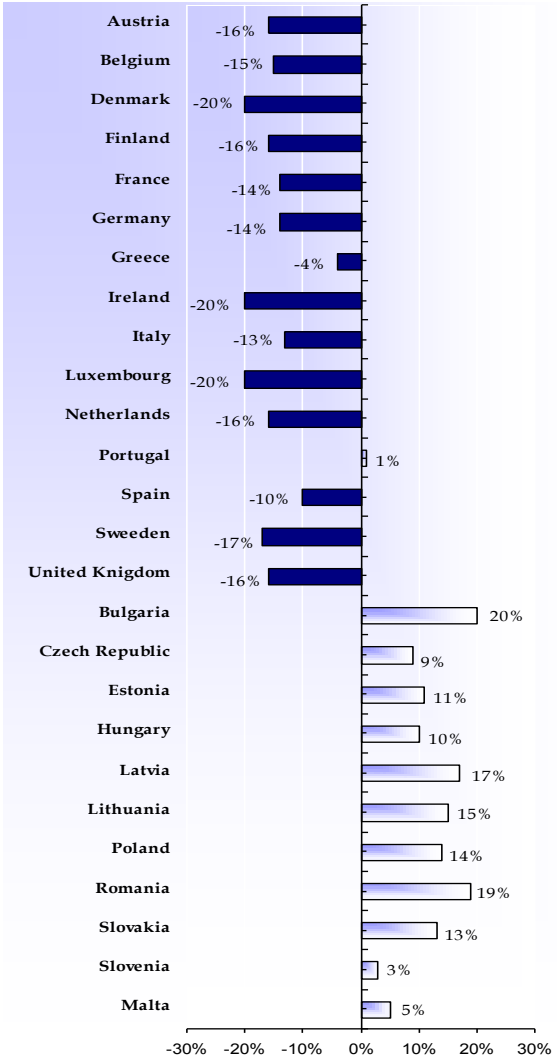
For new member States, the decline of heavy, energy intensive industries in the 90s, allowed to lower considerably the level of GHG emissions that was in 2005 35.4 % below their 1990 level, that is to say quite far below EU Kyoto and post-Kyoto objective. With the economic recover in recent years, that is expected to continue in the baseline scenario with average GDP growth rates close from 4 % in average over 2005-2020 period, GHG emissions in new Member States should re-increase 11.5 % up to 2020, from NEMESIS baseline evolutions, but stay 28 below their 1990 level. The only exceptions are Malta and Slovenia where GHG emissions are in 2020 respectively 55 and 15 % above their 1990 level.

Figure 7: GHG emissions in EU-27 countries compared to 1990

100 in 1990	Actual (EEA) 2005	Baseline 2020
Austria	118.1	125
Belgium	97.9	106
Denmark	92.2	82
Germany	81.3	75
Finland	97.5	92
France	98.1	104
Greece	125.3	130
Ireland	125.3	134
Italy	112.1	120
Luxembourg	100.0	112
Netherlands	98.8	112
Portugal	140.4	147
Spain	152.2	162
Sweeden	92.7	109
United Kingdom	84.3	84
Czech Republic	74.2	70
Estonia	48.1	48
Latvia	42.1	61
Lithuania	47.0	67
Hungary	65.4	74
Malta	154.5	155
Poland	68.0	68
Slovenia	100.5	115
Slovakia	66.3	87
Romania	54.4	77
EU-15	98.0	100
EU-12	64.6	72
EU-27	**89.7**	**92.7**

It is this 'Hot Air' reserve in new Member States, and also the solidarity principle consisted to do not penalize EU countries with GDP per capita below EU average that conducted EU authorities adopting the burden sharing agreement for sectors not covered by EU ETS (Figure 8) where emissions reduction, that represent about 60 % to EU GHG emissions, are costly to achieve.

Figure 8: Reduction targets per country for non EU-ETS sectors for 2020 compared to 2005



As one can see on figure 8, this burden sharing agreement will allow new Member States increase their GHG emissions in non EU ETS sectors from 3 (Malta) to 20 % (Bulgaria), while in EU-15 countries emissions should be reduced about 15 to 20 % in northern countries, objectives being less important for southern countries.

For CO_2 emissions only, that represent more than 80 % of overall GHG emissions, evolutions displayed in Figure 9 are of course similar: For 2020, EU-27 countries should globally situate 1.7 % below their 1990 level, EU-15 countries increasing 3 % their emissions above this 1990 level, and new Member States reducing 20 % their emissions compared to it.

Figure 9: CO2 emissions in EU-27 countries compared to 1990 level

100 in 1990	Actual (EEA) 2005	Baseline 2020
Austria	130.2	135
Belgium	102.5	110
Denmark	94.0	79
Germany	84.3	75
Finland	99.5	90
France	107.5	112
Greece	135.9	133
Ireland	149.0	163
Italy	114.7	121
Luxembourg	107.8	120
Netherlands	111.5	124
Portugal	156.9	164
Spain	164.5	168
Sweeden	92.6	108
United Kingdom	94.9	92
Czech Republic	78.1	71
Estonia	45.0	44
Latvia	40.5	60
Lithuania	38.6	52
Hungary	85.2	95
Malta	144.2	144
Poland	86.2	83
Slovenia	114.7	122
Slovakia	63.1	82
Romania	60.3	85
EU-15	104.3	103
EU-12	74.9	80
EU-27	**97.9**	**98.3**

3.1- Results of scenario S1: 'no recycling of auctioning revenue'

In this first scenario, there is no recycling of auctioning revenue. This scenario allows consequently, when compared to results for scenarios S2 and S3, to assess for the efficiency of recycling schemes used in these last scenarios. It shows also the direct economic costs of increasing carbon price in EU ETS sectors and of imposing stronger limitations on GHG emissions in non EU ETS ones.

The simulation results show a decrease of EU-27 GDP of 0.65 % in 2020 (see table below) reflecting the fall in private demand that follows the rise of carbon value in EU ETS sectors that reaches 2005 euros against 24 euros in the baseline scenario. The permits price is increasing during the phase 2013 to 2020 attaining 61.17€/ton CO2-equivalent in 2020. This permits price is associated to the emission commitment introduced in the *Climate Action and Renewable Energy Package*. This rise in carbon value represents auctioning revenue of about 102.21 billion euros for European states, taken on EU ETS firms that are constrained to increase their production price. This increases final consumptions prices by 1.15 %, and households reduce 0.6 % their final consumption, with an equivalent reduction of their real disposable income.

Table 15: Macroeconomic results for Europe EU-27 in 2020 (S1)

Main Macroeconomic Results	
GDP	-0.65
Final consumption	-0.60
Firms' investment	-2.18
Energy consumption	-7.68
Extra-EU Exports	-0.86
Extra-EU Imports	-1.09
Private R&D	1.33
Employment	-0.17

Energy consumption falls 7.68 %, as a consequence of high EU ETS carbon value, but also of carbon taxation in non EU ETS sectors. Firms' investment reduces –2.18 %, that is more than the fall in production and reflects the complementarity existing between energy consumption and investment in capital goods in NEMESIS. Conversely the evolution of employment, which falls only 0.17 %, reflects favorable substitutions from energy and capital-intensive production techniques, to more labor intensive ones.

Table 16: Impact on the sectoral industrial production in 2020

Agriculture	-1,41	**Food, Drink & Tobacco**	-0,35
Coal and Coke	0,00	**Tex., Cloth & Footw.**	-0,66
Oil and Gas Extraction	-2,76	**Paper & Printing Prod.**	-0,55
Gas Distribution	-9,53	**Rubber and Plastic**	-1,15
Refined Oil	-19,33	**Other manufactures**	-0,89
Electricity	1,48	**Construction**	-1,61
Water supply	-0,19	**Distribution**	-0,86
Ferr & Non Ferrous Metals	-2,10	**Lodging and Catering**	-0,48
Non Metallic Min. Prod.	-1,51	**Inland Transports**	-0,57
Chemicals	-0,86	**Sea and Air Transport**	-1,90
Metal Products	-1,34	**Other Transport**	-0,76
Agri & Industr. Mach.	-1,71	**Communication**	-0,46
Office Machines	-1,51	**Bank, Finance and Insurance**	-0,56
Electrical Goods	-1,04	**Other Market Services**	-0,74
Transport Equipment	-1,15	**Non market Services**	-0,06

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

This higher balance price for carbon in EU ETS and the introduction of carbon penalties in non EU ETS impact also negatively on EU-27 foreign competitiveness, with a 0.86 % fall of exports in 2020. The reduction of EU-27 imports, by–1.09 % in 2020, due to the lower internal consumption and the fall of energy imports, allows nevertheless EU external balance to evolve favorably. There is an also positive impact onto private R&D expenditures that rise 1.33 %, with a much more important impact in EU ETS, energy intensive sectors, and especially power sector, where productivity improvements offset partially the cost of carbon penalty.

EU ETS, energy intensive sectors encounter nevertheless a sharp fall of production in EU-27 for 2020, with–19.33 % for refined oil, 9.53 % for gas distribution sector and about 1 to 2 % for most of other energy intensive industries. Conversely, the development of renewable energies production in power sector, and favorable substitutions between energy products, induces a 1.48 % increase in electricity production. Fall of production in non EU ETS sectors are less important, and closely related to GDP evolution.

At country level, table 17 show contrasted impacts for GDP, that range in 2020 from +0.20 % in Luxembourg, to –0.41 % in France, –0.61 % in Sweden and Belgium, –1.23 % in Portugal, and –1.46 % in Spain.

Table 17: Macroeconomic impacts for the EU15 countries in 2020

	GDP	Final consumption	Firms' investment	Energy consumption	Private R&D	Employment
Austria	-0.58	-0.94	-2.33	-5.89	1.24	-0.04
Belgium	-0.61	-0.25	-3.38	-9.27	1.49	0.47
Denmark	-0.02	0.30	-1.95	-6.02	0.36	0.22
Germany	-0.30	-0.42	-1.10	-6.21	1.02	-0.09
Finland	-0.39	-0.23	-0.67	-7.32	0.89	0.07
France	-0.41	-0.26	-2.01	-10.97	1.22	0.30
Greece	-1.07	-1.15	-1.74	-5.64	2.15	-0.80
Ireland	-0.34	1.20	-4.40	-6.07	0.79	1.10
Italy	-1.14	-1.26	-3.25	-8.08	1.87	-0.46
Luxembourg	0.20	0.38	-1.03	-5.15	-0.99	1.20
Netherlands	-0.98	0.18	-4.57	-11.98	1.43	0.89
Portugal	-1.23	-1.21	-1.60	-3.52	1.91	-0.61
Spain	-1.46	-1.71	-2.93	-8.40	2.45	-0.59
Sweeden	-0.61	-0.59	-0.49	-5.72	1.37	-0.19
United Kingdom	-0.65	-0.24	-2.16	-7.03	1.91	0.27
EU27	-0.65	-0.60	-2.18	-7.68	1.33	-0.17

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

There are remarkable facts:

- fall in GDP are mainly driven by private consumption especially, for example in Austria (-0.98 %), in Portugal (–1.21 %) and in Spain (–1.71 %), where the consumer price index rise importantly;
- Greece and the Netherlands encounter the worse performances for investment with respectively –1.50 % and –1.63 % in 2020.
- pressure on employment differs across European countries. The EU-15 Member countries are less impacted by the drop of employment with –0.59 % in Spain, –0.46 % in Italy, –0.29 % in Hungary and –0.09 % in Germany. There is even increases of employment in several EU-15 countries as France (+0.30), Belgium (+0.47 %), Netherlands (+0.89 %) or Ireland (+1.30 %), as a consequence of the positive substitution effects already quoted above It contrasts with evolutions in new member States where employment decreases everywhere except Lithuania;
- fall in GDP tends to be similar for States with a GDP per capita below EU average than for EU-15 countries, with –0.09 % in Estonia, –0.20 % in Hungary, and –0.96 % in Poland and Slovenia. But, it is two of these countries, Slovakia and Romania that experience the highest negative impact on GDP with respectively –2.27 % and –2.20 % in 2020, due to importance of coal in their energy system. These countries encounter also the biggest fall in employment, with respectively–3 % and –1.85 %, and also –0.82 % in Poland.

Table 18: Macroeconomic impacts in 2020 for Members with a GDP per capita below EU-27 average

	GDP	Final consumption	Firms' investment	Energy consumption	Private R&D	Employment
Czech Republic	-0.78	-0.52	-1.70	-2.99	1.40	-0.13
Estonia	-0.09	-0.05	-1.64	-3.95	1.50	0.22
Latvia	-0.54	-0.68	-1.62	-4.68	1.19	-0.36
Lithuania	0.01	0.17	-0.99	-2.33	-0.57	0.30
Hungary	-0.21	-1.09	-2.77	-6.79	2.49	-0.29
Malta	-0.20	-0.54	-0.86	-2.05	1.46	-0.12
Poland	-0.96	-1.22	-1.81	-3.97	3.47	-0.82
Slovenia	-0.96	-0.84	-1.35	-3.28	1.85	-0.44
Slovakia	-2.27	-4.39	-6.77	-10.74	7.72	-3.00
Romania	-2.20	-1.31	-8.89	-13.47	8.53	-1.85
EU27	-0.65	-0.60	-2.18	-7.68	1.33	-0.17

Scenario shows finally the necessity to recycle auctioning revenues for lowering GDP, final consumption and employment costs of the "Climate Action and Renewable Energy Package". It shows also the necessity to use part of these revenues for the purpose of community solidarity to lower the policy cost in new member states as Romania, Slovakia and Poland, where EU ETS sectors represent a large part of economic activities with also higher energy intensity of these activities and of GDP, than in EU-15 countries.

Table 19: GHG emissions reductions in EU-27 countries for 2020, S1 scenario

	2020					
	Baseline (100 in 2005)			Reductions (in % dev. from baseline)		
	EU ETS	non EU ETS	Total	EU ETS	non EU ETS	Total
Austria	104.5	107.5	106.4	-9.0	-16.2	-13.6
Belgium	110.7	105.6	107.6	-9.7	-16.7	-13.8
Denmark	85.3	97.8	91.7	-11.3	-7.4	-9.3
Germany	83.5	100.8	92.1	-19.4	-11.4	-14.8
Finland	90.9	100.7	95.1	-9.4	-10.8	-10.1
France	108.1	105.1	105.9	-8.9	-12.3	-11.3
Greece	101.8	109.0	104.9	-11.1	-7.9	-9.6
Ireland	96.6	114.2	108.1	2.6	-23.0	-15.1
Italy	112.1	100.1	105.5	-10.4	-11.0	-10.7
Luxembourg	99.4	122.7	112.3	-6.6	-30.7	-21.3
Netherlands	113.1	113.0	112.9	-7.3	-22.1	-14.4
Portugal	105.9	102.0	104.0	-12.6	-3.0	-7.9
Spain	95.5	116.7	106.7	-12.8	-15.7	-14.4
Sweeden	136.5	101.5	115.8	-12.2	-10.8	-11.5
United Kingdom	96.5	104.4	100.8	-7.8	-13.9	-10.9
Czech Republic	79.6	123.8	95.5	-10.4	-10.8	-10.1
Estonia	84.4	149.7	101.2	-9.9	-23.2	-14.8
Latvia	141.9	152.5	148.7	-10.3	-19.3	-16.1
Lithuania	149.7	140.7	145.0	-7.1	-14.3	-10.7
Hungary	101.9	124.7	114.4	-13.2	-11.4	-12.0
Malta	99.5	106.1	100.7	-7.5	-0.3	-6.1
Poland	91.5	113.9	99.7	-10.1	-3.4	-6.9
Slovenia	117.7	112.3	114.5	-6.2	-5.9	-6.0
Slovakia	130.2	134.9	131.6	-14.7	-19.6	-16.5
Romania	137.9	147.3	139.7	-19.7	-26.6	-21.8
EU-27	98.8	107.6	103.3	-11.9	-13.0	-12.3

For GHG emissions, the evolutions in scenario S1 compared to baseline figures for 2020 show that the EU-27 12.3 % reduction effort in % deviation from baseline, is quite fairly shared between EU-15 and new Member States countries, the former group of countries reducing in average more its emissions than this later, despite lower growth of GHG emissions level over the period 2005-2020. Emissions in non EU ETS sectors, that reduce 13 % for EU-27, are constraint in countries by the burden sharing agreement, while emissions for EU ETS, that reduce 11.9 % for EU-27, result in the different countries mainly from their respective marginal abatement costs for CO_2 and from the

free trade that occurs inside and between European industries and countries for CO_2 allowances in scenario S1.

Table 20: CO2 emissions reductions in EU-27 countries for 2020, S1 scenario

	2020					
	Baseline			Objectives		
	EU ETS	Non EU ETS	Total	EU ETS	Non EU ETS	Total
Austria	100.6	106.9	104.3	-9.5	-20.7	-16.3
Belgium	109.3	105.2	106.9	-10.2	-19.7	-15.5
Denmark	82.0	93.7	87.2	-13.0	-12.5	-12.5
Germany	81.4	99.3	89.4	-20.7	-14.2	-17.4
Finland	86.1	99.5	91.0	-10.5	-14.8	-12.2
France	102.1	104.6	103.8	-10.7	-17.9	-15.6
Greece	93.5	108.7	99.2	-13.3	-10.3	-12.0
Irland	90.8	128.3	110.3	2.0	-36.3	-21.3
Italy	110.2	99.1	104.5	-11.1	-13.4	-12.2
Luxembourg	98.8	121.7	111.0	-6.6	-34.1	-22.8
Netherlands	108.8	113.7	110.8	-7.9	-26.2	-16.1
Portugal	105.0	103.4	104.3	-13.1	-3.7	-9.1
Spain	91.5	116.1	102.7	-13.8	-21.6	-17.8
Sweeden	135.1	97.7	115.5	-13.1	-15.3	-14.1
United Kingdom	93.6	102.5	98.2	-8.1	-17.6	-12.6
Czech Republic	76.7	127.6	92.1	-11.0	-13.6	-12.1
Estonia	83.2	164.1	99.2	-10.5	-29.5	-16.8
Latvia	136.0	168.2	153.9	-10.7	-26.0	-19.9
Lithuania	124.8	152.6	137.6	-11.8	-21.4	-16.7
Hungary	94.7	129.3	112.3	-16.7	-14.3	-15.2
Malta	98.9	105.2	100.0	-7.6	-0.3	-6.3
Poland	86.9	117.0	95.9	-10.9	-4.2	-8.2
Slovenia	100.4	114.0	107.0	-8.4	-9.2	-8.8
Slovakia	123.8	147.5	132.0	-15.3	-22.8	-18.2
Romania	126.2	179.3	140.4	-22.3	-34.9	-26.6
EU-27	94.6	107.3	100.5	-13.0	-16.9	-14.9

Table 20, that displays the results for CO_2 emissions, show little higher reductions for CO_2 than for global GHG emissions in 2020, with for EU-27 in deviation from baseline, reductions on 13 % in EU ETS sectors, 16.9 % in non EU ETS sectors and 14.9 % for global emissions CO_2. Results *per* country for CO_2 are comparable to results obtained for global GHG emissions, since in EU ETS sectors only CO_2 is constraint, and in non EU ETS sectors the emissions constraint bears on all gases but sole CO_2 emissions were taxed, as NEMESIS cannot deal with taxes for other GHG categories than CO_2.

As a result of the absence of constraint for emissions other than CO_2 in EU ETS sector, the post Kyoto target in not exactly reaches in 2020, the reduction of GHG emissions for EU-27 being 19.1 % compared to 1990 only. An additional abatement effort, for example 10 % additional reduction of non-GHG emissions in EU ETS sectors, should thus be imposed through statutory measures, to reach the 20 % post-Kyoto objective.

For the other objectives of the EU 'Climate Action and Renewable Energy Package', one can state equally that the targets are also closely satisfied in this scenario S1.

For the share on renewables in final energy consumption (table 21) reaches in 2020 18 % for EU-27 countries, against 8.5 % in 2005 and 13 % in 2020 in the baseline scenario. The high oil and gas prices in the baseline scenario, in conjunction to the high prices for carbon in EU ETS and non EU ETS sectors in scenario S1, creates thus very strong incentives for renewable energies development, even without introduction of additional specific policies for renewable energy sources, as foreseen in the EU renewable energies directive proposal. The 20 % renewable share could be reached from 2022 if one will pursue the scenario horizon until 2025, with this time a 25 % reduction objective for GHG emissions in 2025 compared to 1990, as it was studied with NEMESIS[10].

[10] Results for 2025, are available on request for S1, S2 and S3 scenarios.

Table 21: Share of renewables in EU-27 countries, scenario S1

1 = 100%		Baseline	S1
	2005	2020	
Austria	0.24	0.26	0.34
Belgium	0.05	0.07	0.15
Denmark	0.16	0.26	0.20
Germany	0.08	0.15	0.14
Finland	0.27	0.30	0.35
France	0.11	0.12	0.21
Greece	0.07	0.10	0.12
Irland	0.03	0.07	0.21
Italy	0.08	0.11	0.15
Luxembourg	0.02	0.05	0.23
Netherlands	0.04	0.06	0.13
Portugal	0.19	0.21	0.23
Spain	0.09	0.13	0.20
Sweeden	0.33	0.34	0.38
United Kingd	0.03	0.06	0.11
Czech Repub	0.06	0.09	0.15
Estonia	0.20	0.19	0.38
Latvia	0.37	0.34	0.48
Lithuania	0.16	0.18	0.26
Hungary	0.06	0.07	0.11
Malta	0.00	0.04	0.05
Poland	0.09	0.12	0.13
Slovenia	0.16	0.16	0.20
Slovakia	0.06	0.06	0.10
Romania	0.17	0.17	0.40
EU27	0.09	0.13	0.18

Source: NEMESIS model

Nevertheless, the development of renewable is unequal between countries. Most of EU countries reach their renewable energies potential as defined by European Commission (COM(2008) 30 final) for 2020, or approach it by less than 3 %. Apart Slovakia, where 4 % renewable share could be reach in 2020, the other exception is Denmark, where there exists for 2020 an additional 10 % potential compared to scenario S1 results.

For 10 % biofuels in transports gasoline and diesel consumption objective for 2020, the high price of petroleum products, allow also reaching the objective in scenario S1, with a share of 12 % for EU-27. Eight European countries stay below 8 % share in 2020 (Belgium, Finland, Greece, Ireland, Portugal, Malta, Slovenia and Romania), for which additional policies for biofuels could be envisaged.

Table 22: Biofuels share in transport gasoline and diesel, scenario S1

1 = 100%		Baseline	S1
	2005	2020	
Austria	0.00	0.06	0.12
Belgium	0.00	0.05	0.05
Denmark	0.00	0.07	0.08
Germany	0.02	0.06	0.08
Finland	0.00	0.05	0.05
France	0.01	0.05	0.09
Greece	0.00	0.05	0.05
Irland	0.00	0.05	0.07
Italy	0.00	0.06	0.10
Luxembourg	0.00	0.07	0.09
Netherlands	0.00	0.07	0.09
Portugal	0.00	0.05	0.06
Spain	0.01	0.09	0.17
Sweeden	0.02	0.07	0.09
United Kingd	0.00	0.06	0.11
Czech Repul	0.00	0.09	0.14
Estonia	0.00	0.07	0.09
Latvia	0.00	0.08	0.15
Lithuania	0.00	0.06	0.14
Hungary	0.00	0.08	0.09
Malta	0.00	0.02	0.02
Poland	0.00	0.09	0.10
Slovenia	0.00	0.05	0.06
Slovakia	0.01	0.09	0.19
Romania	0.00	0.03	0.04
EU27	0.00	0.06	0.12

3.2- Results of scenario S2: Recycling of auctioning revenue by a cut in employers' social contributions rate

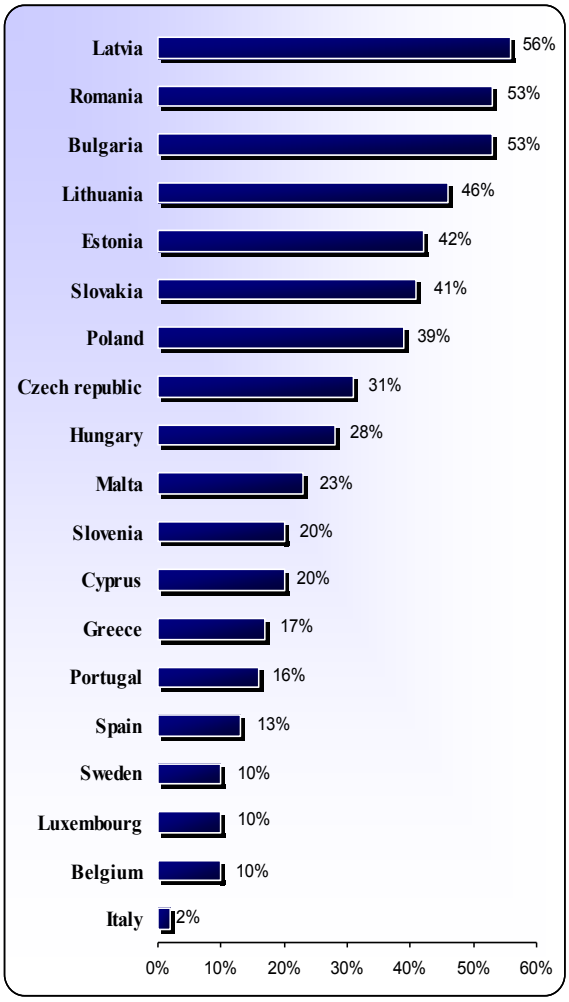
This scenario S2 deeper the analysis by a recycling of auctioning revenues generated by the implementation of the *Climate Action and Renewable Energy Package*. The recycling takes into account the community solidarity principle. 90 % of auctioning rights are distributes accordingly to Member States share in 2005 emissions in the EU ETS, and the remaining 10 % are redistributed to low income countries, taking into account their GDP per capita and their overall growth expectations, with the repartition displayed on figure below.

This distribution of auctioning rights results in significant reduction of overall direct costs experienced by member states with a low GDP per capita, with limited direct costs increases for richer countries. Revenues generated by auctioning are actually substantial. They reach 08 % European GDP in 2020, for a carbon price of 74.34€/ton CO_2-equivalent, and they can exceed 1.5 % GDP in countries as Romania, Slovakia and Poland that beneficiate the more from the solidarity principle.

These auctioning revenues are used in scenario 2 to lower employers' social contribution rate. This recycling consisting in transferring part of labor taxation onto carbon taxation was actually extensively studied in economic literature, for the reason that labor is generally considered too heavy taxed in European countries, leading to high unemployment rates.

The recycling of auctioning revenues by a reduction in employers' social contribution rate in scenario S2, allows in that direction to obtain a 'double dividend Environment/Employment' at EU-27 level, with a rise of total employment of 1.43 % in 2020, compared to a decrease of –0.17 % in the scenario S1.

Figure 10: Percentage of increase in allowances to be auctioned for the purpose of community solidarity



Source: European Commission (Proposal Directive to Improve and extend the Greenhouse Gas Emission Allowance Trading System COM (2008))

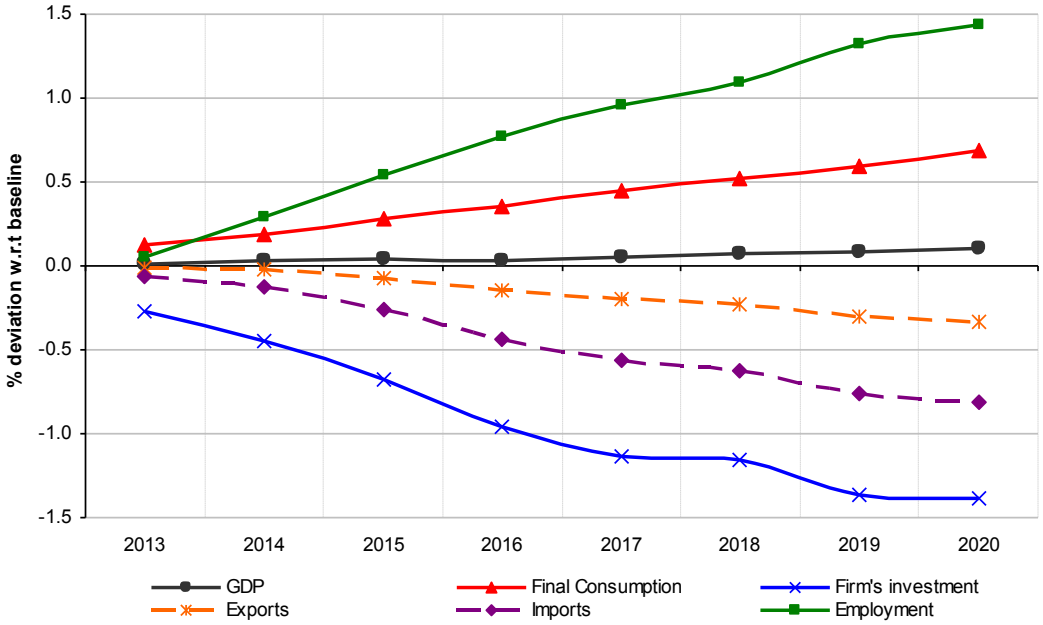
Table 23: Macroeconomic results for Europe EU27 in 2020

Main Macroeconomic Results	
GDP	0.11
Final consumption	0.68
Firms' investment	-1.39
Energy consumption	-7.15
Extra-EU Exports	-0.04
Extra-EU Imports	-0.80
Private R&D	0.17
Employment	1.43

deviation w.r.t. baseline (in percentage poi

Source: NEMESIS model

Figure 11: Macroeconomic trends for Europe EU27



Source: Nemesis model

This increase in employment level is caused by the direct substitution effect due to the lowering of labor costs, and by the consecutive rise in final consumption (+ 0.68 %) due to the fall in unemployment rate. There is even a slight positive impact on GDP in that scenario that rises 0.11 % in 2020, for the main reason that fossil fuels imports are reduced, and replaced by increased consumption for goods produced principally inside Europe. Also, reduced labor costs allow decrease production costs, despite the fact that carbon price is high and increases But this high energy (and oil) prices context renders more profitable substitutions from labor to energy, that result in a decrease of –0.89 % of consumption price index, that come reduce the negative impacts of the policy on European exports, that fall only 0.04 %, against 0.89 % in scenario S1.

The results of S2 scenario are of course contrasted among European countries, as a consequence of different energy consumption and production systems, added to different labour market structure. In EU-15, some countries have still negative impact on GDP, as Spain (–0.77 %), Netherlands (–0.55 %) or France (–0.18 %), but all have important employment gains, that reach from 0.08 % in Sweden to 1.99 % in Luxembourg and 0.59 % in France, 0.91 % in Germany and 1.03 % in United Kingdom, the biggest European economies.

Table 24: Macroeconomic impacts for the EU-15 countries in 2020

	GDP	Final consumption	Firms' investment	Energy consumption	Private R&D	Employment
Austria	-0.15	-0.55	-2.00	-5.74	0.41	0.46
Belgium	-0.18	0.26	-3.12	-9.19	0.70	1.11
Denmark	1.27	3.60	-0.58	-4.48	-0.33	1.45
Germany	0.59	0.63	-0.30	-5.74	-0.37	0.91
Finland	0.38	1.26	0.32	-6.61	-0.26	1.07
France	-0.18	-0.02	-1.85	-10.99	0.66	0.59
Greece	0.16	-0.23	-0.81	-4.93	-0.92	1.62
Ireland	0.17	2.14	-3.98	-5.83	0.04	1.71
Italy	-0.21	-0.10	-2.48	-7.43	0.52	0.70
Luxembourg	0.80	1.37	-0.61	-4.91	-1.80	1.99
Netherlands	-0.55	0.29	-4.31	-11.88	0.18	1.54
Portugal	-0.47	-1.21	-1.14	-2.97	-0.28	0.70
Spain	-0.77	-0.84	-2.27	-8.16	1.15	0.30
Sweeden	-0.37	-0.23	-0.44	-5.70	0.89	0.08
United Kingdom	-0.12	0.19	-1.74	-6.83	0.67	1.03
EU27	0.11	0.68	-1.39	-7.15	0.17	1.43

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 25: Macroeconomic impacts in 2020 for Members with a GDP per capita below EU-27 average in 2020

	GDP	Final consumption	Firms' investment	Energy consumption	Private R&D	Employment
Czech Republic	3.82	8.12	2.99	1.22	-5.01	6.27
Estonia	2.03	5.37	1.33	-1.25	-3.50	4.12
Latvia	0.00	0.26	-1.15	-4.42	-0.25	0.35
Lithuania	1.44	2.76	0.19	-1.67	-2.95	2.02
Hungary	1.54	2.37	-1.01	-5.69	-0.54	2.42
Malta	0.58	1.73	0.00	-1.28	-2.14	1.63
Poland	2.61	4.19	1.81	-0.67	-4.04	4.01
Slovenia	-0.02	0.90	-0.39	-2.33	0.06	0.91
Slovakia	1.32	-0.13	-4.39	-8.83	3.26	0.59
Romania	4.58	10.27	-2.73	-8.63	-0.89	7.96
EU27	0.11	0.68	-1.39	-7.15	0.17	1.43

Most importantly, new EU Member States, with GDP per capita below European average, are now the countries that know the most positive impacts from the policy. This contrasts strongly from the results of scenario S1, and demonstrates that the implementation of the EU *Climate Action and Renewable Energy Package*, with the community solidarity principle that was retained here, could represent a true opportunity for employment and growth in these countries. For CO_2 and GHG emissions, results for scenario 2 are very similar than for scenario 1 (and also scenario 3) for the reason that emissions reduction objective are identical in all scenarios. These results will consequently not be presented, the important being that the scenario conform again the EU post-Kyoto objectives in terms of GHG emissions and burden sharing agreement for non EU ETS sector. For renewable objectives also, the changes are too small to be commented.

3.3- Results of scenario S3: Recycling of auctioning revenue combining a cut in employers' social contributions rate and a subsidy to firms' private R&D

This scenario S3 differs from scenario S2 only in the way auctioning revenue is recycled. The auctioning revenue is recycled in two ways: A reduction, as in scenario S2, of employers' social contributions rate, and a general subsidy to private R&D expenditures

limited to 30 %. The rate of R&D subsidy was limited to 30 % in order to stay in orders of plausible magnitude.

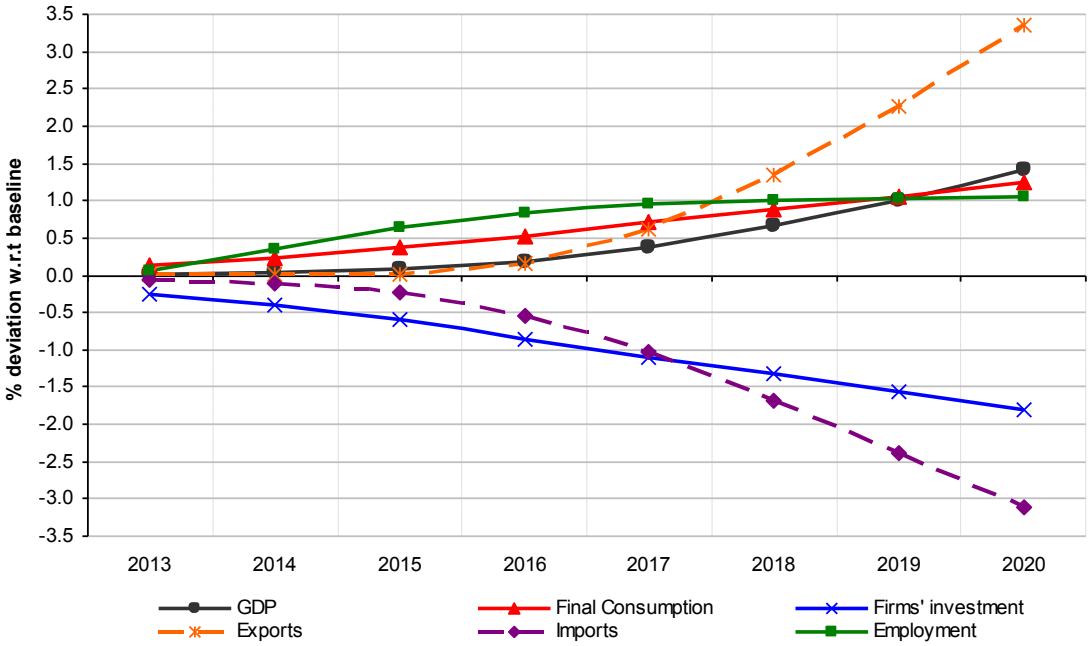
Table 26: Macroeconomic results for Europe EU27 in 2020

Main Macroeconomic Results	
GDP	1.41
Final consumption	1.25
Firms' investment	-1.80
Energy consumption	-8.46
Extra-EU Exports	3.34
Extra-EU Imports	-3.10
Private R&D	25.90
Employment	1.07

deviation w.r.t. baseline (in percentage poin

Source: NEMESIS model

Figure 12: Macroeconomic trends for Europe EU27



Source: Nemesis model

The results of this last scenario for 2020, presented in figure above for EU-27, show this time very positive evolutions for all macro-economic indicators. The European GDP increases about +1.41 % in 2020, compared to a decrease of 0.65 % in scenario S1 and an increase limited to +0.11 % in S2. The strong stimulation of firms R&D expenditures in this scenario, that increase 26 % provoke important positive competitiveness effects, that traduces by a decrease of consumer (and GDP) price index of 3.5 %. The underlying mechanisms are the rise in total factor productivity and in the quality of goods produced resulting from important process and product innovations by European firms.

The decrease in consumer price is re-enforced, as in scenario S2, by the fall in labour cost implied by the cut in firms' social contributions rate. It results in a rise of 1.25 % of households' private consumption, to compare to –0.60 % in scenario S1 and only +0.68 % in scenario S2.

The results for employment, when compared to those of scenario 2 are more contrasted. It increases +1.07 %, against 1.43 % in scenario S2 for the reason that the

subsidy to R&D come limit the importance of the cut in employers' social contribution rate, and that the increase in productivity come also reduce employment.

This reduced positive impact on employment of S3 compared to scenario S2 is nevertheless compensated by better evolutions for GDP and final consumption. The impacts, compare to S2, are also very positive for external trade, with a rise of exports of 3.34 % (against -0.04 % for S2) and a fall of imports 3.1 % (against only -0.8 % in S2). This increased competitiveness of European countries in scenario S3 should then guaranty durable macroeconomic and employment gains, compared to S2 where part of the benefices could be only transitory.

Table 27: Macroeconomic impacts for EU-15 countries in 2020

	GDP	Final consumption	Firms' investment	Energy consumption	Private R&D	Employment
Austria	1.51	0.59	-2.25	-7.54	18.50	0.50
Belgium	1.73	0.81	-3.49	-9.84	26.71	0.75
Denmark	1.21	1.22	-2.23	-7.77	23.76	0.23
Germany	1.76	1.13	-0.65	-7.27	22.40	0.64
Finland	2.85	1.28	-0.97	-7.70	16.34	0.66
France	0.77	0.33	-2.15	-11.64	12.14	0.33
Greece	1.74	1.49	-0.35	-4.88	66.11	2.00
Ireland	1.62	2.31	-4.89	-7.36	37.19	1.53
Italy	1.91	1.48	-2.41	-8.81	71.56	0.80
Luxembourg	2.04	1.42	-3.28	-7.99	33.11	0.35
Netherlands	1.19	1.49	-4.14	-12.25	39.09	1.61
Portugal	-0.24	-0.90	-2.32	-4.98	71.29	-0.10
Spain	0.43	-0.06	-2.64	-10.01	74.09	-0.10
Sweeden	1.73	-0.18	-0.82	-7.29	4.48	-0.24
United Kingdom	1.30	1.36	-1.72	-7.87	28.80	1.00
EU27	1.41	1.25	-1.80	-8.46	25.90	1.07

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

This scenario S3 aims thus reaching an authentic triple dividend 'growth-environment-employment', showing the interest to couple a policy designed for fighting climate change and promoting renewable energies use across European countries, with a policy accelerating technological change. It contributes also achieving the Barcelona R&D target (increasing R&D to 3 % European GDP) included in the Lisbon Agenda of EU-27.

Furthermore, scenario S3 allow reaching the *Climate Action and Renewable Energy Package* objectives for GHG emissions reduction at a lower price for carbon, with 57.12 €/ton CO2-equivalent in 2020, against respectively 61.17€ and 74.34€ in scenarios S1 and S2.

Table 28: Macroeconomic impacts in 2020 for Members with a GDP per capita below EU-27 average

	GDP	Final consumption	Firms' investment	Energy consumption	Private R&D	Employment
Czech Republic	4.15	5.99	0.75	-2.11	66.34	4.05
Estonia	3.71	3.76	-0.43	-3.81	69.10	2.51
Latvia	0.91	-0.54	-2.74	-6.21	73.05	-0.46
Lithuania	1.63	2.66	-0.62	-2.75	66.72	1.79
Hungary	4.12	2.61	-1.63	-6.55	70.17	2.11
Malta	1.75	1.83	-0.39	-2.97	69.72	1.28
Poland	2.70	3.07	0.07	-2.93	67.56	2.85
Slovenia	1.31	1.21	-1.12	-4.61	70.92	0.70
Slovakia	0.53	-0.82	-6.11	-10.74	78.89	-0.50
Romania	5.93	8.61	-3.68	-10.23	71.13	6.48
EU27	1.41	1.25	-1.80	-8.46	25.90	1.07

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Scenario S3 shows also, as scenario S2, that the most favorable macro-economic impacts occur in new Member States (see tables 27 and 28). The impacts on GDP and final consumption are positive in every countries and generally superiors than in scenario S2. As in scenario S2, in S3 the new member states beneficiate of the highest cuts in employers' social contribution rate, but also, in S3, of the highest increases in R&D expenditures and productivity. R&D expenditures, which level is initially very low in the baseline scenario, increase about 70 % in average in new member states, against 26 % only for EU-27 average. Scenario S3 demonstrates again that the implementation of the EU *Climate Action and Renewable Energy Package* and its community solidarity principle, could represent a true opportunity for employment and growth in countries with GDP per capita below European average.

4- Comparison of NEMESIS results with Commission assessment for EU Climate Action and Renewable Energy Package of 27 February 2008 (SEC(2008) 85 Vol. II)

The 'Package of implementation measures for the EU's objectives on climate change and renewable energies for 2020' issued by European Commission the 23 January 2008, was accompanied with an impact assessment by Commission staff (SEC(2008) 85/3), that was updated the 27 February 2008 (SEC(2008) 85 Vol. II) to account for 'the high energy import price environment of recent years, sustained economic growth and new policies and measures implemented in the Member States.

For purpose of comparison, the assessment for EU *Climate Action and Renewable Energy Package* presented here was based on common assumptions concerning notably:

- GDP growth in line with DG ECFIN expectations (2.2 % on average up to 2030);
- Inflation rate;
- renewables shares;
- policy measures up to 2006 that were included in the baseline scenario;
- directive of the nuclear phase-out;

- continuation of the EU ETS over the projection period without extension to new sectors, with a balance carbon price of 20€ (2005)/t CO_2 to 22€ (2005)/t CO_2 in 2020.

Commission staff assessment was realized notably GAINS and PRIMES model for energy, GHG emissions, and renewables indicators, and GEM-E3 general equilibrium model for the calculation of economic impacts of the scenarios that were studied.

For policy experimentations, NEMESIS baseline was notably calibrated onto PRIMES results for key indicators:

- renewable share evolution in power generation sector and electricity production from Geothermal, Hydraulic and Nuclear sources;
- biofuels share in gasoline and diesel;
- fuel inputs in power generation sector and fuels efficiency factors in power generation and in transport sector (passengers and freight).

Slight differences exist as NEMESIS used slightly higher oil (and gas prices) to account for the most recent context for the price of imported energies.

Table 29: Prices for oil in $ / boe in money of 20005

	2005	2010	2015	2020
PRIMES/GAINS/GEM-E3	54.5	54.5	57.9	61.1
NEMESIS	54.5	92.2	67.8	76

The purpose of this section is then to compare the results of evaluations made by the different model. The comparison will bear only economic indicators as the scenarios studied with the different model follow the same policy objectives for GHG reduction and renewables.

Table 30: Comparison of assessments: 'no Community Solidarity Principle Case'

	PRIMES/GAINS/GEM-E3			NEMESIS S1		
	Change GDP 2020	Change private Consumption 2020	Change Employment 2020	Change GDP 2020	Change private Consumption 2020	Change Employment 2020
EU-27	-0.35%	0.19%	-0.04%	-0.65%	-0.60%	-0.17%
AT	0.00%	0.30%	0.40%	-0.58%	-0.94%	-0.04%
BE	-0.40%	0.20%	0.00%	-0.61%	-0.25%	0.47%
CZ	-1.70%	0.20%	-0.70%	-0.78%	-0.52%	-0.13%
DK	-0.10%	-0.10%	0.40%	-0.02%	0.30%	0.22%
EE	-2.30%	-0.40%	-1.10%	-0.09%	-0.05%	0.22%
FI	-0.60%	0.40%	-0.30%	-0.39%	-0.23%	0.07%
FR	-0.30%	0.10%	0.00%	-0.41%	-0.26%	0.30%
DE	-0.30%	0.10%	-0.10%	-0.30%	-0.42%	-0.09%
EL	-0.80%	-0.20%	-0.30%	-1.07%	-1.15%	-0.80%
HU	-1.50%	-0.80%	-0.40%	-0.21%	-1.09%	-0.29%
IE	0.20%	-0.10%	1.30%	-0.34%	1.20%	1.10%
IT	-0.10%	0.50%	0.30%	-1.14%	-1.26%	-0.46%
LV	-0.90%	-0.80%	-0.20%	-0.54%	-0.68%	-0.36%
LT	-0.60%	0.90%	-0.50%	0.01%	0.17%	0.30%
NL	-0.40%	0.50%	0.10%	-0.98%	0.18%	0.89%
PL	-1.50%	-0.80%	-0.70%	-0.96%	-1.22%	-0.82%
PT	-0.30%	0.40%	-0.10%	-1.23%	-1.21%	-0.61%
RO	-2.40%	1.60%	-0.80%	-2.20%	-1.31%	-1.85%
SK	-1.70%	1.30%	-0.80%	-2.27%	-4.39%	-3.00%
SI	-0.60%	-0.40%	-0.50%	-0.96%	-0.84%	-0.44%
ES	-0.10%	0.70%	0.80%	-1.46%	-1.71%	-0.59%
SE	-0.20%	0.10%	-0.10%	-0.61%	-0.59%	-0.19%
UK	-0.30%	-0.10%	-0.10%	-0.65%	-0.24%	0.27%

In table 30, NEMESIS scenario S1, where the EU *Climate Action and Renewable 1Energy Package* is introduced without recycling of auctioning revenue by States, is compared with PRIMES/GAINS/GEM-E3 scenario 'Cost efficiency case with auctioning in all EU ETS and no revenue generation in the non ETS), that differ mainly from NEMESIS scenario S1 mainly by the fact that there is auctioning revenue recycling through increases in households' disposable income (increase in social transfers).

The GDP cost with NEMESIS for 2020 is close from twice the cost measured by GEM-E3 (-0.65 % against -0.35 %) for the reason that there is no recycling of auctioning revenues in NEMESIS. In GEM-E3, there is a 0.19 % rise in Households' final consumption, resulting from the increase in real disposable income resulting from the rise in social transfers, while final consumption fall 0.6 % in NEMESIS, and follows GDP evolution. For employment changes are respectively -0.04 % for GEM-E3 and -0.17 % for NEMESIS. Fall in employment is less important that the fall in GDP in both models, for the reason that in both models favorable factor substitutions take place for employment implied by the rise in energy prices. For both models, results by country are much contrasted, and similarities can be found for relative GDP and employment changes. The most important differences are of course found for final consumption, boosted in GEM-E3 by revenue recycling on households' real disposable income.

Table 31 compares NEMESIS results for scenario S2 where this time auctioning revenues are recycled with an equivalent fall in employers' social contributions. Furthermore, following the solidarity principle, there the distribution of auctioning rights takes into account GDP/capita discrepancies between Member States. The comparison is made with PRIMES/GAINS/GEM-E3 scenario 'Cost efficiency case with auctioning in all EU ETS and distribution auctioning rights taking into account GDP/capita and no revenue generation in the non ETS'. It is the same scenario that the proceeding, but with

also application of the solidarity principle for distribution of auctioning revenue among Member States.

Table 31: Comparison of assessments, 'Community Solidarity Principle Case'

	PRIMES/GAINS/GEM-E3			NEMESIS S2		
	Change GDP 2020	Change private Consumption 2020	Change Employment 2020	Change GDP 2020	Change private Consumption 2020	Change Employment 2020
EU-27	-0.34%	0.21%	-0.09%	0.11%	0.68%	1.43%
AT	0.00%	0.10%	0.05%	-0.15%	-0.55%	0.46%
BE	-0.40%	0.10%	0.00%	-0.18%	0.26%	1.11%
CZ	-2.00%	6.20%	-1.60%	3.82%	8.12%	6.27%
DK	-0.10%	-0.10%	0.40%	1.27%	3.60%	1.45%
EE	-3.10%	8.20%	-2.40%	2.03%	5.37%	4.12%
FI	-0.60%	0.40%	-0.30%	0.38%	1.26%	1.07%
FR	-0.30%	0.00%	0.00%	-0.18%	-0.02%	0.59%
DE	-0.30%	0.00%	-0.10%	0.59%	0.63%	0.91%
EL	-0.80%	0.90%	-0.40%	0.16%	-0.23%	1.62%
HU	-1.50%	-0.40%	-0.50%	1.54%	2.37%	2.42%
IE	0.20%	-0.10%	1.30%	0.17%	2.14%	1.71%
IT	-0.10%	0.30%	0.30%	-0.21%	-0.10%	0.70%
LV	-0.90%	-0.60%	-0.30%	0.00%	0.26%	0.35%
LT	-0.60%	0.50%	-0.50%	1.44%	2.72%	2.42%
NL	-0.40%	0.20%	0.10%	-0.55%	0.29%	1.54%
PL	-1.50%	1.60%	-0.90%	2.61%	4.19%	4.01%
PT	-0.30%	0.50%	-0.10%	-0.47%	-1.21%	0.70%
RO	-2.40%	7.90%	-1.40%	4.58%	10.27%	7.96%
SK	-1.80%	2.50%	-1.00%	1.32%	-0.13%	0.59%
SI	-0.70%	0.40%	-0.70%	-0.02%	0.90%	0.91%
ES	0.00%	0.40%	0.90%	-0.77%	-0.84%	0.30%
SE	-0.20%	0.00%	-0.10%	-0.37%	-0.23%	0.08%
UK	-0.30%	-0.20%	-0.10%	-0.12%	0.19%	1.03%

For GEM-E3, at EU-27 level, there is very little change in GDP and employment compared to the former scenario, for the reason that the only difference between scenarios stays is repartition of auctioning revenue among Member States. For NEMESIS on the contrary, we find this time a positive evolution for GDP, with +0.11 % (against -0.65 % previously) and +1.43 % for employment (against -0.17 %). NEMESIS illustrates the double dividend Environment/Employment that most studies aiming redeploying fiscal charges from employment toward environment put in evidence. By contrast, the recycling of auctioning revenue with increased social transfers to households in GEM-E3 does not allow reaching such double dividend. The reason is that increase in social transfer first increases household final consumption, and then GDP and employment, but in longer term, higher production costs resulting from the introduction of carbon penalties bear on European competitiveness. In NEMESIS, the reduction in employers' social contributions rate allows increasing employment and consequently final consumption a GDP, without deterioration of European firms competitiveness. There is even a net gain in terms of GDP, that traduce the reduction of energy imports that are replace by the consumption of goods produced with a lesser content in imports than energy products.

At country level, the results of the two models demonstrate the important economic gains that European countries below European average for their GDP *per* capita could get from the implementation of the EU *Climate Action and Renewable 1Energy Package*, if the solidarity principle between European countries is applied. For Romania, final consumption gains establish in 2020 7.9 % for GEM-E3, and 10.27 % for NEMESIS. These gains reach respectively 6.2 and 8.12 % in Czech Republic, 8.2 and 5.37 % in

Estonia and 1.6 and 4.19 % in Poland. For these last countries, that figure among the countries that beneficiate the more from the increase in CO_2 allowances to be auctioned in ETS for the purpose of community solidarity, one can finally state that the increase of revenues from auctioning, while rising the level of final consumption, do not change results for GDP, or very slightly, and have limited and mitigated impacts on employment. It results from the general equilibrium properties of this model that imply very inelastic labor supply and strong eviction of internal demand stimulation by prices and external trade. NEMESIS was unemployment prevails on labor market will, certainly have deliver differences in results, but this GEM-E3 scenario was not studied with NEMESIS and no comparisons are possible here.

This comparison of PRIMES/GAINS/GEM-E3 and NEMESIS assessments for EU *Climate Action and Renewable 1Energy Package*, with two models, one general equilibrium and one econometric, that have very different mechanisms but share same principal assumptions for baseline evolutions have shown a lot of convergence, and complementarities in results:

- the implementation of EU *Climate Action and Renewable 1Energy Package* should have only a limited cost in terms of GDP for EU-27, or even a negative one, depending the way auctioning revenues are recycled by Member States;
- important gains could be obtained for consumers if recycling of auctioning revenue is used to increase households' disposable income;
- employment could also be importantly stimulated if the recycling of revenue, and the stimulation of households' final consumption, passes through a reduction of labor cost (NEMESIS S2 scenario) and not by an increase in social transfer that could impact negatively on European firms competitiveness;
- lastly the application of the community solidarity principle could EU *Climate Action and Renewable 1Energy Package* represent an important opportunity for growth and employment in EU countries with GDP below European average like Romania and Poland, that are also very carbon intensive.

5- Appendix: Additional results for scenarios S1, S2 & S3

Scenario s1

Table 32: Impact on the levels of price in the EU15 countries in 2020

	Consumption price	Exports price	Imports prices	Wage rate
Austria	0,99	1,00	0,54	0,63
Belgium	1,22	1,18	0,73	0,84
Denmark	0,57	0,73	0,43	0,62
Germany	0,42	0,82	0,47	0,22
Finland	0,77	0,75	0,25	0,56
France	0,45	0,82	-0,18	0,18
Greece	1,91	1,84	0,90	1,44
Ireland	0,89	0,83	0,75	1,03
Italy	1,14	1,20	0,14	0,64
Luxembourg	0,40	0,31	0,32	0,44
Netherlands	0,52	1,50	0,62	0,35
Portugal	1,84	1,84	1,04	1,36
Spain	0,48	1,62	0,14	-0,22
Sweeden	1,96	1,31	0,69	1,57
United Kingdom	1,76	1,60	1,18	1,37
EU27	1,15	1,16	0,52	0,71

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 33: Impact on the levels of price in 2020in the Member states with a GDP per capita below the EU27 average

	Consumption price	Exports price	Imports prices	Wage rate
Czech Republic	0,98	1,25	0,96	0,67
Estonia	1,79	2,47	1,06	1,56
Latvia	0,57	1,63	1,05	0,17
Lithuania	-0,22	0,69	0,12	-0,39
Hungary	1,82	1,52	1,15	1,17
Malta	3,19	1,96	1,35	2,75
Poland	2,97	2,65	1,60	2,40
Slovenia	1,65	1,41	0,65	1,31
Slovakia	4,90	4,36	1,74	3,22
Romania	3,00	4,26	1,46	1,46
EU27	1,15	1,16	0,52	0,71

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 34: Impacts on External trade and competitiveness in the EU27 countries in 2020

	Exports	Imports
Austria	-0,84	-1,42
Belgium	-1,24	-1,73
Denmark	-0,23	-0,43
Germany	-0,86	-1,21
Finland	-0,97	-0,99
France	-0,75	-1,85
Greece	-1,50	-1,23
Ireland	-0,65	-0,58
Italy	-0,98	-2,08
Luxembourg	-0,51	-0,65
Netherlands	-1,63	-1,64
Portugal	-1,47	-1,22
Spain	-1,25	-2,38
Sweeden	-1,32	-1,14
United Kingdom	-1,24	-0,25
EU27	-1,05	-1,32

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

	Exports	Imports
Czech Republic	-1,08	-0,94
Estonia	-0,41	-0,41
Latvia	-2,40	-1,22
Lithuania	-1,78	-0,66
Hungary	-1,38	-1,01
Malta	-0,38	0,51
Poland	-2,02	-0,40
Slovenia	-1,14	-0,62
Slovakia	-3,61	-3,01
Romania	-3,30	-2,21
EU27	-1,05	-1,32

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 35: Emissions in the EU15 countries in 2020

	Power generation	Energy branch	Agriculture	Industry	Residential	Tertiary	Transport
Austria	-6,92	-15,32	-16,72	-10,55	-16,69	-13,17	-12,08
Belgium	-9,15	-20,97	-7,12	-8,74	-15,83	-10,15	-8,90
Denmark	-15,95	-11,94	-9,90	-4,03	-13,22	-8,53	-4,52
Germany	-25,58	-18,01	-7,46	-9,69	-9,01	-7,04	-6,96
Finland	-5,91	-35,81	-17,18	-13,21	-11,29	-10,43	-4,41
France	0,79	-42,34	-5,91	-8,05	-14,05	-8,38	-8,49
Greece	-15,24	-9,66	-8,60	-5,51	-6,30	-4,82	-9,62
Ireland	8,59	-0,61	-17,23	-10,26	-21,88	-16,28	-17,20
Italy	-10,93	-30,28	-5,17	-6,47	-7,88	-8,23	-8,16
Luxembourg	4,35	0,00	-24,25	-10,70	-13,42	-13,21	-11,77
Netherlands	-4,53	-18,65	-26,54	-9,94	-16,72	-16,22	-12,08
Portugal	-16,71	-4,18	-2,19	-5,23	-4,37	-3,17	-5,91
Spain	-16,93	-23,08	-10,60	-9,65	-13,43	-11,85	-14,57
Sweeden	-17,07	-14,83	-5,91	-9,21	-14,75	-9,94	-6,35
United Kingdom	-6,98	-11,07	-14,85	-6,83	-12,70	-7,69	-9,58
EU27	-13,75	-18,94	-9,95	-9,50	-12,27	-8,60	-9,98

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 36: Emission in the new accessing Members states in 2020

	Power generation	Energy branch	Agriculture	Industry	Residential	Tertiary	Transport
Czech Republic	-11,36	-3,53	-17,16	-9,28	-16,85	-1,22	-9,97
Estonia	-9,77	-5,39	-21,18	-17,89	-34,68	-18,43	-14,93
Latvia	-10,33	-2,05	-14,51	-12,99	-25,95	-21,53	-13,28
Lithuania	-14,73	-3,49	-10,54	-7,17	-13,57	-11,79	-13,36
Hungary	-17,26	-13,72	-12,62	-12,01	-14,88	-7,50	-10,21
Malta	-9,68	0,00	0,00	-2,37	-0,51	0,12	-5,92
Poland	-10,58	-6,84	-3,75	-11,18	-6,15	-2,62	-4,08
Slovenia	-7,89	0,00	-4,90	-7,83	-8,57	-3,88	-6,08
Slovakia	-16,44	-10,83	-20,98	-15,13	-22,30	-16,09	-15,68
Romania	-22,57	-19,35	-28,93	-21,48	-18,63	-20,37	-28,17
EU27	-13,75	-18,94	-9,95	-9,50	-12,27	-8,60	-9,98

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 37: Repartition of the emission reduction between the EU-ETS and the non EU-ETS sectors with the EU27 Member states

	EU-ETS sectors	Non EU-ETS sectors	Total emissions
Austria	-9,48	-20,74	-16,28
Belgium	-10,15	-19,71	-15,54
Denmark	-12,95	-12,49	-12,45
Germany	-20,71	-14,23	-17,42
Finland	-10,53	-14,80	-12,23
France	-10,69	-17,87	-15,62
Greece	-13,27	-10,25	-12,01
Ireland	1,95	-36,27	-21,30
Italy	-11,07	-13,45	-12,19
Luxembourg	-6,60	-34,05	-22,77
Netherlands	-7,93	-26,18	-16,12
Portugal	-13,11	-3,70	-9,10
Spain	-13,76	-21,60	-17,83
Sweeden	-13,14	-15,26	-14,06
United Kingdom	-8,05	-17,57	-12,62
EU27	-13,00	-16,90	-14,86

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

	EU-ETS sectors	Non EU-ETS sectors	Total emissions
Czech Republic	-10,98	-13,62	-12,08
Estonia	-10,50	-29,51	-16,78
Latvia	-10,73	-25,96	-19,85
Lithuania	-11,82	-21,37	-16,67
Hungary	-16,69	-14,25	-15,21
Malta	-7,63	-0,34	-6,28
Poland	-10,88	-4,19	-8,20
Slovenia	-8,37	-9,17	-8,78
Slovakia	-15,35	-22,83	-18,25
Romania	-22,26	-34,91	-26,57
EU27	-13,00	-16,90	-14,86

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 38: Impact on the sectoral industrial production in 2020

Agriculture	-1,41	**Food, Drink & Tobacco**	-0,35
Coal and Coke	0,00	**Tex., Cloth & Footw.**	-0,66
Oil and Gas Extraction	-2,76	**Paper & Printing Prod.**	-0,55
Gas Distribution	-9,53	**Rubber and Plastic**	-1,15
Refined Oil	-19,33	**Other manufactures**	-0,89
Electricity	1,48	**Construction**	-1,61
Water supply	-0,19	**Distribution**	-0,86
Ferr & Non Ferrous Metals	-2,10	**Lodging and Catering**	-0,48
Non Metallic Min. Prod.	-1,51	**Inland Transports**	-0,57
Chemicals	-0,86	**Sea and Air Transport**	-1,90
Metal Products	-1,34	**Other Transport**	-0,76
Agri & Industr. Mach.	-1,71	**Communication**	-0,46
Office Machines	-1,51	**Bank, Finance and Insurance**	-0,56
Electrical Goods	-1,04	**Other Market Services**	-0,74
Transport Equipment	-1,15	**Non market Services**	-0,06

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 39: Impact on the production price in the EU27 sectors in 2020

Agriculture	0,91	**Food, Drink & Tobacco**	0,79
Coal and Coke	0,00	**Tex., Cloth & Footw.**	0,79
Oil and Gas Extraction	-0,03	**Paper & Printing Prod.**	1,72
Gas Distribution	0,58	**Rubber and Plastic**	1,37
Refined Oil	0,86	**Other manufactures**	1,08
Electricity	5,31	**Construction**	1,38
Water supply	1,47	**Distribution**	0,95
Ferr & Non Ferrous Metals	5,44	**Lodging and Catering**	0,90
Non Metallic Min. Prod.	6,46	**Inland Transports**	0,81
Chemicals	2,39	**Sea and Air Transport**	6,20
Metal Products	1,88	**Other Transport**	1,07
Agri & Industr. Mach.	1,12	**Communication**	1,02
Office Machines	0,42	**Bank, Finance and Insurance**	0,91
Electrical Goods	1,13	**Other Market Services**	0,91
Transport Equipment	1,07	**Non market Services**	0,94

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 40: Impact of total sectoral exports in the EU27 in 2020

Agriculture	0,00	**Food, Drink & Tobacco**	-0,30
Coal and Coke	0,00	**Tex., Cloth & Footw.**	-0,43
Oil and Gas Extraction	-5,77	**Paper & Printing Prod.**	-0,73
Gas Distribution	0,00	**Rubber and Plastic**	-0,99
Refined Oil	-13,37	**Other manufactures**	-0,72
Electricity	0,96	**Construction**	-0,83
Water supply	0,00	**Distribution**	-0,58
Ferr & Non Ferrous Metals	-1,80	**Lodging and Catering**	-0,47
Non Metallic Min. Prod.	-2,03	**Inland Transports**	-0,53
Chemicals	-0,86	**Sea and Air Transport**	-2,81
Metal Products	-1,26	**Other Transport**	-0,39
Agri & Industr. Mach.	-1,25	**Communication**	-0,57
Office Machines	-0,67	**Bank, Finance and Insurance**	-0,61
Electrical Goods	-0,87	**Other Market Services**	-0,59
Transport Equipment	-0,91	**Non market Services**	-0,28

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 41: Impacts on the sectoral imports in the EU27 in 2020

Agriculture	0,00	**Food, Drink & Tobacco**	-0,19
Coal and Coke	0,00	**Tex., Cloth & Footw.**	-0,02
Oil and Gas Extraction	-8,34	**Paper & Printing Prod.**	0,09
Gas Distribution	0,00	**Rubber and Plastic**	-0,30
Refined Oil	-8,15	**Other manufactures**	-0,68
Electricity	3,09	**Construction**	-0,87
Water supply	0,00	**Distribution**	-0,01
Ferr & Non Ferrous Metals	0,26	**Lodging and Catering**	0,12
Non Metallic Min. Prod.	0,79	**Inland Transports**	-0,07
Chemicals	0,14	**Sea and Air Transport**	1,24
Metal Products	-0,33	**Other Transport**	0,03
Agri & Industr. Mach.	-0,68	**Communication**	-0,25
Office Machines	-1,40	**Bank, Finance and Insurance**	-0,06
Electrical Goods	-1,03	**Other Market Services**	-0,23
Transport Equipment	-0,83	**Non market Services**	0,23

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 42: Impacts on the total sectoral employment in the EU27 in 2020

Agriculture	-2,90	**Food, Drink & Tobacco**	0,92
Coal and Coke	0,00	**Tex., Cloth & Footw.**	1,07
Oil and Gas Extraction	-1,02	**Paper & Printing Prod.**	-0,58
Gas Distribution	-13,00	**Rubber and Plastic**	-0,71
Refined Oil	-16,75	**Other manufactures**	0,06
Electricity	-0,87	**Construction**	-0,45
Water supply	-5,52	**Distribution**	-0,07
Ferr & Non Ferrous Metals	-2,99	**Lodging and Catering**	-0,19
Non Metallic Min. Prod.	-1,57	**Inland Transports**	0,32
Chemicals	-2,18	**Sea and Air Transport**	-0,86
Metal Products	-0,77	**Other Transport**	-0,95
Agri & Industr. Mach.	-1,52	**Communication**	0,28
Office Machines	-1,89	**Bank, Finance and Insurance**	-0,36
Electrical Goods	0,05	**Other Market Services**	0,62
Transport Equipment	-0,55	**Non market Services**	0,42

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 43: Impacts on the sectoral energy consumption in the EU27 in 2020

Agriculture	-6,40	**Food, Drink & Tobacco**	-3,72
Coal and Coke	0,00	**Tex., Cloth & Footw.**	-3,95
Oil and Gas Extraction	-3,16	**Paper & Printing Prod.**	-1,52
Gas Distribution	-9,57	**Rubber and Plastic**	-2,32
Refined Oil	-20,69	**Other manufactures**	-2,40
Electricity	-8,18	**Construction**	-3,54
Water supply	-3,04	**Distribution**	-3,58
Ferr & Non Ferrous Metals	-3,40	**Lodging and Catering**	-3,07
Non Metallic Min. Prod.	-2,77	**Inland Transports**	-6,93
Chemicals	-4,13	**Sea and Air Transport**	-8,68
Metal Products	-2,93	**Other Transport**	-7,23
Agri & Industr. Mach.	-4,66	**Communication**	-3,31
Office Machines	-4,03	**Bank, Finance and Insurance**	-7,61
Electrical Goods	-3,47	**Other Market Services**	-3,16
Transport Equipment	-3,40	**Non market Services**	-1,60

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Scenario S2

Table 44: Impact on the levels of price in the EU15 countries in 2020

	Consumption price	Exports price	Imports prices	Wage rate
Austria	-0,16	0,14	-0,33	-0,26
Belgium	0,13	0,39	-0,05	-0,04
Denmark	0,61	0,19	0,34	1,27
Germany	-1,06	-0,31	-0,57	-0,83
Finland	-0,34	-0,18	-0,88	-0,10
France	-0,47	0,13	-1,02	-0,57
Greece	-1,93	-0,46	-0,79	-1,88
Ireland	0,07	0,16	0,13	0,59
Italy	-0,41	0,09	-0,91	-0,51
Luxembourg	-0,49	-0,26	-0,36	-0,14
Netherlands	-1,16	0,31	-0,41	-0,93
Portugal	-1,25	-0,03	-0,34	-1,20
Spain	-1,27	0,56	-0,86	-1,41
Sweeden	1,26	0,70	-0,03	1,06
United Kingdom	0,13	0,45	0,25	0,13
EU27	-0,89	0,00	-0,50	-1,06

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 45: Impact on the levels of price in the Members states with a GDP per capita below EU average in 2020

	Consumption price	Exports price	Imports prices	Wage rate
Czech Republic	-4,96	-2,34	-1,54	-2,67
Estonia	-2,71	-0,04	-0,58	-1,15
Latvia	-1,04	0,81	0,13	-1,19
Lithuania	-2,90	-0,84	-1,44	-2,00
Hungary	-1,62	-0,49	-0,30	-1,28
Malta	-2,54	-1,45	-0,79	-2,24
Poland	-5,58	-2,41	-1,67	-5,39
Slovenia	-0,31	0,08	-0,38	-0,19
Slovakia	0,37	1,73	-0,11	-0,28
Romania	-7,32	-1,03	-2,16	-7,92
EU27	-0,89	0,00	-0,50	-1,06

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 46: Impacts on External trade and competitiveness in the EU27 in 2020

	Exports	Imports
Austria	-0,22	-0,96
Belgium	-0,76	-1,35
Denmark	-0,11	0,59
Germany	-0,14	-0,69
Finland	-0,38	-0,28
France	-0,27	-1,54
Greece	0,19	-1,09
Ireland	-0,24	-0,01
Italy	-0,26	-1,50
Luxembourg	-0,21	-0,03
Netherlands	-0,98	-1,31
Portugal	-0,14	-1,09
Spain	-0,57	-1,93
Sweeden	-0,91	-0,71
United Kingdom	-0,52	0,03
EU27	-0,34	-0,81

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

	Exports	Imports
Czech Republic	1,44	1,39
Estonia	0,82	1,09
Latvia	-1,92	-0,82
Lithuania	-0,71	-0,11
Hungary	-0,03	0,20
Malta	0,37	-0,82
Poland	1,77	0,20
Slovenia	-0,21	0,16
Slovakia	-1,71	-1,86
Romania	0,22	1,82
EU27	-0,34	-0,81

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 47: Impact on the sectoral industrial production in 2020

Agriculture	-0,36	**Food, Drink & Tobacco**	0,07
Coal and Coke	0,00	**Tex., Cloth & Footw.**	0,98
Oil and Gas Extraction	-2,65	**Paper & Printing Prod.**	0,34
Gas Distribution	-8,66	**Rubber and Plastic**	-0,04
Refined Oil	-18,98	**Other manufactures**	0,10
Electricity	2,75	**Construction**	-0,86
Water supply	1,75	**Distribution**	0,00
Ferr & Non Ferrous Metals	-1,05	**Lodging and Catering**	0,30
Non Metallic Min. Prod.	-0,59	**Inland Transports**	0,41
Chemicals	0,04	**Sea and Air Transport**	-1,27
Metal Products	-0,54	**Other Transport**	0,04
Agri & Industr. Mach.	-0,81	**Communication**	0,57
Office Machines	-0,55	**Bank, Finance and Insurance**	0,25
Electrical Goods	-0,13	**Other Market Services**	0,03
Transport Equipment	-0,23	**Non market Services**	0,13

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 48: Impact on the production price in the EU27 sectors in 2020

Agriculture	-1,00	**Food, Drink & Tobacco**	-0,82
Coal and Coke	0,00	**Tex., Cloth & Footw.**	-1,51
Oil and Gas Extraction	-1,97	**Paper & Printing Prod.**	0,08
Gas Distribution	-1,14	**Rubber and Plastic**	-0,49
Refined Oil	-0,84	**Other manufactures**	-0,84
Electricity	4,35	**Construction**	-0,49
Water supply	-1,42	**Distribution**	-1,21
Ferr & Non Ferrous Metals	4,63	**Lodging and Catering**	-0,80
Non Metallic Min. Prod.	5,41	**Inland Transports**	-1,37
Chemicals	1,02	**Sea and Air Transport**	5,46
Metal Products	0,30	**Other Transport**	-0,63
Agri & Industr. Mach.	-0,63	**Communication**	-1,09
Office Machines	-0,69	**Bank, Finance and Insurance**	-1,09
Electrical Goods	-0,54	**Other Market Services**	-0,81
Transport Equipment	-0,48	**Non market Services**	-1,30

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 49: Impact of total sectoral exports in the EU27 in 2020

Agriculture	0,00	**Food, Drink & Tobacco**	0,11
Coal and Coke	0,00	**Tex., Cloth & Footw.**	0,75
Oil and Gas Extraction	-5,37	**Paper & Printing Prod.**	0,01
Gas Distribution	0,00	**Rubber and Plastic**	-0,18
Refined Oil	-12,87	**Other manufactures**	0,08
Electricity	1,89	**Construction**	0,06
Water supply	0,00	**Distribution**	0,19
Ferr & Non Ferrous Metals	-1,12	**Lodging and Catering**	0,31
Non Metallic Min. Prod.	-1,36	**Inland Transports**	0,55
Chemicals	-0,23	**Sea and Air Transport**	-2,40
Metal Products	-0,50	**Other Transport**	0,09
Agri & Industr. Mach.	-0,47	**Communication**	0,49
Office Machines	-0,12	**Bank, Finance and Insurance**	0,40
Electrical Goods	-0,11	**Other Market Services**	0,30
Transport Equipment	-0,15	**Non market Services**	0,47

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 50: Impacts on the sectoral imports in the EU27 in 2020

Agriculture	0,00	**Food, Drink & Tobacco**	-0,24
Coal and Coke	0,00	**Tex., Cloth & Footw.**	0,26
Oil and Gas Extraction	-8,34	**Paper & Printing Prod.**	0,28
Gas Distribution	0,00	**Rubber and Plastic**	-0,20
Refined Oil	-8,15	**Other manufactures**	-0,30
Electricity	3,09	**Construction**	-0,73
Water supply	0,00	**Distribution**	-0,21
Ferr & Non Ferrous Metals	0,26	**Lodging and Catering**	0,32
Non Metallic Min. Prod.	0,79	**Inland Transports**	-0,13
Chemicals	0,14	**Sea and Air Transport**	1,45
Metal Products	-0,33	**Other Transport**	-0,04
Agri & Industr. Mach.	-0,68	**Communication**	0,62
Office Machines	-1,40	**Bank, Finance and Insurance**	-0,19
Electrical Goods	-1,03	**Other Market Services**	-0,18
Transport Equipment	-0,83	**Non market Services**	-0,27

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 51: Impacts on the total sectoral employment in the EU27 in 2020

Agriculture	-0,35	**Food, Drink & Tobacco**	2,60
Coal and Coke	0,00	**Tex., Cloth & Footw.**	6,26
Oil and Gas Extraction	-0,91	**Paper & Printing Prod.**	0,66
Gas Distribution	-12,90	**Rubber and Plastic**	1,64
Refined Oil	-15,00	**Other manufactures**	3,07
Electricity	0,05	**Construction**	1,16
Water supply	-3,43	**Distribution**	1,86
Ferr & Non Ferrous Metals	-1,04	**Lodging and Catering**	1,13
Non Metallic Min. Prod.	-0,01	**Inland Transports**	3,70
Chemicals	-0,69	**Sea and Air Transport**	1,57
Metal Products	0,90	**Other Transport**	0,41
Agri & Industr. Mach.	0,91	**Communication**	2,55
Office Machines	-1,13	**Bank, Finance and Insurance**	1,83
Electrical Goods	2,16	**Other Market Services**	2,25
Transport Equipment	1,68	**Non market Services**	1,02

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 52: Impacts on the sectoral energy consumption in the EU27 in 2020

Agriculture	-6,40	**Food, Drink & Tobacco**	-3,72
Coal and Coke	0,00	**Tex., Cloth & Footw.**	-3,95
Oil and Gas Extraction	-3,16	**Paper & Printing Prod.**	-1,52
Gas Distribution	-9,57	**Rubber and Plastic**	-2,32
Refined Oil	-20,69	**Other manufactures**	-2,40
Electricity	-8,18	**Construction**	-3,54
Water supply	-3,04	**Distribution**	-3,58
Ferr & Non Ferrous Metals	-3,40	**Lodging and Catering**	-3,07
Non Metallic Min. Prod.	-2,77	**Inland Transports**	-6,93
Chemicals	-4,13	**Sea and Air Transport**	-8,68
Metal Products	-2,93	**Other Transport**	-7,23
Agri & Industr. Mach.	-4,66	**Communication**	-3,31
Office Machines	-4,03	**Bank, Finance and Insurance**	-7,61
Electrical Goods	-3,47	**Other Market Services**	-3,16
Transport Equipment	-3,40	**Non market Services**	-1,60

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 53: Sectoral level of emissions in the EU15 Members countries in 2020

	Power generation	Energy branch	Agriculture	Industry	Residential	Tertiary	Transport
Austria	-7,45	-15,98	-16,44	-10,67	-16,56	-13,10	-11,97
Belgium	-9,88	-21,42	-6,86	-8,95	-15,58	-10,02	-8,75
Denmark	-13,31	-10,74	-10,56	-3,37	-11,95	-8,76	-3,67
Germany	-29,37	-18,05	-7,00	-9,92	-8,39	-7,16	-6,54
Finland	-4,43	-35,53	-17,22	-13,50	-10,45	-10,68	-3,74
France	0,45	-42,91	-5,72	-8,42	-13,95	-8,13	-8,59
Greece	-16,46	-10,46	-7,35	-5,18	-6,12	-4,45	-8,51
Ireland	8,46	-0,65	-17,04	-10,34	-21,35	-16,08	-17,23
Italy	-10,56	-30,47	-4,41	-6,20	-7,09	-8,01	-7,81
Luxembourg	4,83	0,00	-24,30	-10,85	-12,52	-13,11	-11,57
Netherlands	-4,81	-19,25	-26,08	-10,09	-16,77	-16,19	-12,07
Portugal	-18,01	-4,91	-1,00	-4,90	-5,29	-3,27	-5,43
Spain	-19,40	-23,79	-10,06	-9,62	-12,87	-11,65	-14,49
Sweeden	-18,78	-15,28	-5,82	-9,78	-14,76	-10,19	-6,27
United Kingdom	-7,28	-11,29	-14,23	-6,64	-12,57	-7,58	-9,44
EU27	-13,83	-19,23	-9,62	-9,18	-11,88	-8,42	-9,60

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 54: Sectoral level of emissions in 2020in the Members countries with a GDP per capita below the EU27 average

	Power generation	Energy branch	Agriculture	Industry	Residential	Tertiary	Transport
Czech Republic	-6,00	-1,70	-17,34	-6,33	-13,88	0,85	-9,74
Estonia	-7,77	-4,96	-20,26	-16,95	-33,90	-18,23	-12,69
Latvia	-11,66	-2,28	-14,22	-12,95	-25,64	-21,55	-13,25
Lithuania	-16,71	-3,88	-9,55	-7,47	-11,80	-11,81	-13,39
Hungary	-16,01	-14,73	-12,35	-11,84	-14,34	-7,25	-8,57
Malta	-10,22	0,00	0,00	-2,57	0,04	-0,51	-5,98
Poland	-8,27	-6,87	-3,91	-9,56	-8,39	-2,29	-0,54
Slovenia	-6,89	0,00	-4,03	-7,64	-8,05	-3,51	-5,40
Slovakia	-13,55	-10,81	-19,53	-13,96	-21,44	-15,62	-15,97
Romania	-15,27	-20,11	-26,28	-18,47	-11,85	-18,36	-24,51
EU27	-13,83	-19,23	-9,62	-9,18	-11,88	-8,42	-9,60

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 55: Emissions level in the EU-ETS and the non EU-ETS sectors in EU27 Members countries in 2020

	EU-ETS sectors	Non EU-ETS sectors	Total emissions
Austria	-9,93	-20,73	-16,45
Belgium	-10,71	-19,71	-15,78
Denmark	-10,91	-12,45	-11,18
Germany	-23,29	-14,27	-18,72
Finland	-9,63	-14,78	-11,69
France	-11,18	-17,85	-15,76
Greece	-13,83	-10,22	-12,32
Ireland	1,68	-36,27	-21,42
Italy	-10,77	-13,47	-12,05
Luxembourg	-6,73	-34,05	-22,82
Netherlands	-8,24	-26,20	-16,29
Portugal	-13,85	-3,68	-9,52
Spain	-14,67	-21,59	-18,26
Sweeden	-14,23	-15,29	-14,69
United Kingdom	-8,31	-17,58	-12,74
EU27	-12,99	-16,90	-14,86

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

	EU-ETS sectors	Non EU-ETS sectors	Total emissions
Czech Republic	-5,95	-13,59	-9,19
Estonia	-8,56	-29,50	-15,49
Latvia	-11,80	-25,96	-20,28
Lithuania	-13,32	-21,36	-17,41
Hungary	-15,69	-14,23	-14,80
Malta	-7,99	-0,42	-6,58
Poland	-8,68	-4,19	-6,87
Slovenia	-7,61	-9,16	-8,41
Slovakia	-13,31	-22,83	-17,00
Romania	-16,83	-34,80	-23,18
EU27	-12,99	-16,90	-14,86

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Scenario S3

Table 56: Impact on the levels of price in the EU15 countries in 2020

	Consumption price	Exports price	Imports prices	Wage rate
Austria	-3,03	-2,58	-2,58	-2,55
Belgium	-2,58	-2,21	-2,39	-2,15
Denmark	-3,06	-2,45	-2,25	-2,23
Germany	-2,84	-2,61	-2,47	-2,22
Finland	-4,04	-3,47	-3,23	-3,13
France	-2,69	-2,33	-3,02	-2,40
Greece	-4,46	-2,54	-2,77	-3,79
Ireland	-2,35	-2,06	-1,83	-1,39
Italy	-4,71	-3,21	-3,48	-3,87
Luxembourg	-2,96	-1,73	-2,12	-2,67
Netherlands	-3,29	-2,39	-2,60	-2,40
Portugal	-4,01	-2,44	-2,49	-3,59
Spain	-4,96	-2,62	-3,38	-4,40
Sweeden	-1,45	-2,07	-2,25	-1,20
United Kingdom	-2,52	-2,02	-1,78	-1,82
EU27	-3,50	-2,61	-2,62	-3,05

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 57: Impact on the levels of price in the Members states with a GDP per capita below EU average in 2020

	Consumption price	Exports price	Imports prices	Wage rate
Czech Republic	-7,60	-4,56	-3,56	-5,47
Estonia	-5,02	-2,65	-2,50	-3,56
Latvia	-3,64	-0,66	-1,78	-3,70
Lithuania	-5,19	-2,62	-3,49	-4,01
Hungary	-4,33	-2,84	-2,26	-3,45
Malta	-4,54	-2,68	-1,77	-3,89
Poland	-7,69	-4,33	-3,70	-7,04
Slovenia	-3,18	-2,49	-2,57	-2,40
Slovakia	-2,98	-1,22	-2,58	-3,27
Romania	-8,32	-3,09	-3,96	-8,35
EU27	-3,50	-2,61	-2,62	-3,05

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 58: Impacts on External trade and competitiveness in the EU27 countries in 2020

	Exports	Imports
Austria	1,69	-1,38
Belgium	0,58	-1,74
Denmark	1,27	-0,49
Germany	1,56	-1,57
Finland	2,42	-1,64
France	1,44	-2,07
Greece	1,91	0,19
Ireland	1,28	-0,14
Italy	2,08	-2,23
Luxembourg	0,54	-0,71
Netherlands	0,56	-1,11
Portugal	1,05	-1,37
Spain	1,84	-2,85
Sweeden	1,37	-1,25
United Kingdom	1,43	-0,53
EU27	1,40	-1,36

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

	Exports	Imports
Czech Republic	2,33	0,41
Estonia	1,16	0,47
Latvia	-0,93	-0,81
Lithuania	0,05	0,16
Hungary	1,11	0,73
Malta	0,81	0,17
Poland	3,17	0,04
Slovenia	1,66	-0,03
Slovakia	-0,75	-2,19
Romania	1,90	1,41
EU27	1,40	-1,36

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 59: Impact on the sectoral industrial production in 2020

Agriculture	-0,06	**Food, Drink & Tobacco**	-0,16
Coal and Coke	0,00	**Tex., Cloth & Footw.**	1,79
Oil and Gas Extraction	-2,85	**Paper & Printing Prod.**	-0,71
Gas Distribution	-10,44	**Rubber and Plastic**	-1,26
Refined Oil	-18,72	**Other manufactures**	0,15
Electricity	1,52	**Construction**	-1,60
Water supply	1,74	**Distribution**	0,00
Ferr & Non Ferrous Metals	-2,67	**Lodging and Catering**	0,68
Non Metallic Min. Prod.	-2,04	**Inland Transports**	-0,15
Chemicals	1,10	**Sea and Air Transport**	-0,20
Metal Products	-1,79	**Other Transport**	-1,22
Agri & Industr. Mach.	-0,43	**Communication**	0,10
Office Machines	3,40	**Bank, Finance and Insurance**	-0,66
Electrical Goods	1,78	**Other Market Services**	-0,45
Transport Equipment	0,61	**Non market Services**	0,09

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 60: Impact on the production price in the EU27 sectors in 2020

Agriculture	-4,24	**Food, Drink & Tobacco**	-4,28
Coal and Coke	0,00	**Tex., Cloth & Footw.**	-4,52
Oil and Gas Extraction	-4,52	**Paper & Printing Prod.**	-2,76
Gas Distribution	-4,76	**Rubber and Plastic**	-3,80
Refined Oil	-4,83	**Other manufactures**	-3,51
Electricity	0,72	**Construction**	-3,56
Water supply	-4,80	**Distribution**	-3,92
Ferr & Non Ferrous Metals	0,24	**Lodging and Catering**	-3,72
Non Metallic Min. Prod.	0,47	**Inland Transports**	-4,11
Chemicals	-3,29	**Sea and Air Transport**	1,11
Metal Products	-2,77	**Other Transport**	-3,32
Agri & Industr. Mach.	-3,97	**Communication**	-4,40
Office Machines	-3,90	**Bank, Finance and Insurance**	-3,87
Electrical Goods	-4,53	**Other Market Services**	-3,53
Transport Equipment	-3,97	**Non market Services**	-2,88

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 61: Impact of total sectoral exports in the EU27 in 2020

Agriculture	0,00	**Food, Drink & Tobacco**	1,09
Coal and Coke	0,00	**Tex., Cloth & Footw.**	2,23
Oil and Gas Extraction	-5,00	**Paper & Printing Prod.**	0,50
Gas Distribution	0,00	**Rubber and Plastic**	0,16
Refined Oil	-11,11	**Other manufactures**	1,06
Electricity	1,91	**Construction**	1,86
Water supply	0,00	**Distribution**	1,88
Ferr & Non Ferrous Metals	-1,40	**Lodging and Catering**	2,48
Non Metallic Min. Prod.	-0,63	**Inland Transports**	1,57
Chemicals	2,51	**Sea and Air Transport**	-0,28
Metal Products	-0,24	**Other Transport**	0,54
Agri & Industr. Mach.	1,38	**Communication**	2,82
Office Machines	2,63	**Bank, Finance and Insurance**	2,16
Electrical Goods	2,71	**Other Market Services**	1,83
Transport Equipment	2,03	**Non market Services**	0,97

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 62: Impacts on the sectoral imports in the EU27 in 2020

Agriculture	0,00	**Food, Drink & Tobacco**	-2,27
Coal and Coke	0,00	**Tex., Cloth & Footw.**	-1,09
Oil and Gas Extraction	-8,09	**Paper & Printing Prod.**	-1,83
Gas Distribution	0,00	**Rubber and Plastic**	-2,87
Refined Oil	-10,70	**Other manufactures**	-2,19
Electricity	1,02	**Construction**	-2,46
Water supply	0,00	**Distribution**	-1,73
Ferr & Non Ferrous Metals	-2,29	**Lodging and Catering**	-0,85
Non Metallic Min. Prod.	-1,64	**Inland Transports**	-1,68
Chemicals	-3,26	**Sea and Air Transport**	-0,64
Metal Products	-2,53	**Other Transport**	-1,23
Agri & Industr. Mach.	-3,16	**Communication**	-2,27
Office Machines	-3,80	**Bank, Finance and Insurance**	-2,41
Electrical Goods	-4,08	**Other Market Services**	-2,03
Transport Equipment	-3,23	**Non market Services**	-0,66

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 63: Impacts on the total sectoral employment in the EU27 in 2020

Agriculture	0,78	**Food, Drink & Tobacco**	1,64
Coal and Coke	0,00	**Tex., Cloth & Footw.**	5,65
Oil and Gas Extraction	-0,75	**Paper & Printing Prod.**	-0,58
Gas Distribution	-13,73	**Rubber and Plastic**	-0,28
Refined Oil	-15,69	**Other manufactures**	2,36
Electricity	-1,03	**Construction**	-0,09
Water supply	-3,99	**Distribution**	1,35
Ferr & Non Ferrous Metals	-2,67	**Lodging and Catering**	1,04
Non Metallic Min. Prod.	-1,76	**Inland Transports**	2,48
Chemicals	-0,90	**Sea and Air Transport**	2,02
Metal Products	-0,86	**Other Transport**	-1,86
Agri & Industr. Mach.	0,14	**Communication**	1,44
Office Machines	1,93	**Bank, Finance and Insurance**	0,30
Electrical Goods	2,84	**Other Market Services**	1,47
Transport Equipment	1,61	**Non market Services**	0,82

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 64: Impacts on the sectoral energy consumption in the EU27 in 2020

Agriculture	-5,34	**Food, Drink & Tobacco**	-3,40
Coal and Coke	0,00	**Tex., Cloth & Footw.**	-2,56
Oil and Gas Extraction	-2,78	**Paper & Printing Prod.**	-0,80
Gas Distribution	-8,70	**Rubber and Plastic**	-1,30
Refined Oil	-20,50	**Other manufactures**	-1,30
Electricity	-8,22	**Construction**	-2,85
Water supply	-2,06	**Distribution**	-2,80
Ferr & Non Ferrous Metals	-2,41	**Lodging and Catering**	-2,45
Non Metallic Min. Prod.	-2,02	**Inland Transports**	-6,28
Chemicals	-3,51	**Sea and Air Transport**	-8,58
Metal Products	-2,21	**Other Transport**	-7,20
Agri & Industr. Mach.	-3,71	**Communication**	-2,49
Office Machines	-3,25	**Bank, Finance and Insurance**	-7,32
Electrical Goods	-2,40	**Other Market Services**	-2,43
Transport Equipment	-2,26	**Non market Services**	-1,54

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 65: Sectoral level of emissions in the EU15 Members countries in 2020

	Power generation	Energy branch	Agriculture	Industry	Residential	Tertiary	Transport
Austria	-7,46	-19,78	-17,08	-12,61	-15,37	-14,01	-13,09
Belgium	-9,86	-22,62	-8,64	-10,73	-14,73	-10,70	-9,95
Denmark	-16,81	-13,26	-9,89	-6,25	-12,03	-9,26	-5,55
Germany	-24,77	-20,64	-8,38	-11,87	-7,85	-7,38	-7,68
Finland	-8,31	-37,18	-16,43	-15,24	-9,97	-10,65	-6,73
France	0,15	-43,73	-7,00	-10,61	-13,39	-8,74	-9,06
Greece	-13,87	-10,24	-8,46	-5,84	-4,35	-4,85	-8,00
Ireland	8,49	-0,61	-17,48	-12,11	-20,57	-16,87	-19,92
Italy	-9,89	-32,45	-5,84	-8,35	-5,47	-9,58	-9,08
Luxembourg	2,39	0,00	-24,94	-14,01	-12,72	-14,27	-13,59
Netherlands	-4,65	-20,11	-26,94	-11,54	-15,49	-16,66	-12,14
Portugal	-18,17	-5,92	-1,73	-7,56	-3,35	-3,90	-7,12
Spain	-16,54	-24,42	-10,57	-12,39	-11,63	-12,41	-15,62
Sweeden	-17,41	-17,28	-6,79	-11,77	-14,06	-10,84	-7,28
United Kingdom	-6,80	-12,22	-15,60	-8,82	-11,33	-8,12	-10,05
EU27	-12,94	-20,54	-10,35	-11,27	-10,89	-9,11	-10,55

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 66: Emissions level in the EU-ETS and the non EU-ETS sectors in EU27 Members countries in 2020

	Power generation	Energy branch	Agriculture	Industry	Residential	Tertiary	Transport
Czech Republic	-8,96	-5,27	-17,47	-9,40	-14,17	-1,54	-9,77
Estonia	-8,73	-6,64	-20,11	-18,71	-33,89	-19,13	-13,70
Latvia	-10,04	-1,81	-14,60	-14,60	-25,43	-22,47	-13,93
Lithuania	-14,11	-3,62	-10,12	-8,52	-11,57	-12,25	-13,90
Hungary	-15,39	-15,41	-13,53	-13,07	-13,63	-8,32	-9,26
Malta	-8,42	0,00	0,00	-3,75	1,18	-0,09	-6,15
Poland	-9,31	-8,52	-3,88	-11,23	-6,73	-3,20	-3,00
Slovenia	-8,07	0,00	-4,70	-9,85	-7,30	-4,86	-6,55
Slovakia	-15,08	-11,96	-20,79	-15,81	-20,32	-17,77	-17,11
Romania	-16,58	-19,85	-27,98	-20,43	-11,81	-19,26	-25,62
EU27	-12,94	-20,54	-10,35	-11,27	-10,89	-9,11	-10,55

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Table 67: Emissions level in the EU-ETS and the non EU-ETS sectors in EU27 Members countries in 2020

	EU-ETS sectors	Non EU-ETS sectors	Total emissions
Austria	-11,20	-20,67	-16,91
Belgium	-11,30	-19,61	-15,98
Denmark	-14,14	-12,39	-13,11
Germany	-20,71	-14,21	-17,41
Finland	-12,70	-14,78	-13,53
France	-12,11	-17,80	-16,01
Greece	-11,99	-10,13	-11,21
Ireland	0,70	-36,21	-21,76
Italy	-10,75	-13,43	-12,02
Luxembourg	-9,25	-34,02	-23,84
Netherlands	-8,36	-26,00	-16,27
Portugal	-14,61	-3,82	-10,01
Spain	-14,85	-21,57	-18,33
Sweeden	-14,26	-15,32	-14,72
United Kingdom	-8,33	-17,44	-12,65
EU27	-12,99	-16,84	-14,82

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

	EU-ETS sectors	Non EU-ETS sectors	Total emissions
Czech Republic	-9,00	-13,60	-10,94
Estonia	-9,58	-29,52	-16,17
Latvia	-10,91	-25,96	-19,92
Lithuania	-11,60	-21,36	-16,56
Hungary	-15,36	-14,24	-14,66
Malta	-7,25	-0,42	-5,98
Poland	-9,89	-4,19	-7,61
Slovenia	-9,01	-9,16	-9,08
Slovakia	-14,87	-22,75	-17,93
Romania	-18,14	-34,59	-23,91
EU27	-12,99	-16,84	-14,82

deviation w.r.t. baseline (in percentage points)

Source: NEMESIS model

Appendix: The NEMESIS Model

1. General Overview

The NEMESIS model (New Econometric Model for Environment and Sustainable development Implementation Strategies) is an econometric macro/sectoral model built by a European research consortium that was financed mainly by the directorate of the European Commission. It can be used for several purposes, including:

- Assessment of structural policies, mainly environmental and R&D policies.
- Studies of short and medium term consequences of a wide spectrum of economic policies.
- Macro and sectoral "forecasts" for short/medium-term up to 8 years; building baseline scenarios (for up to 30 years).

Three principal characteristics of the model distinguish it from others used for similar analysis:

- An energy-environment module which transforms activity indicators from the macro model at a sectoral level into energy relevant indexes with price effects and pollutants emissions: CO_2, SO_2, NO_X, HFC, PFC and CF_6.
- Five types of conversion matrices for interlinking: final consumption, investment goods, intermediate consumption, energy-environment and technological transfers. These are necessary because goods/services produced by firms are often used in "bundles" in final demand.
- The supply side block, which incorporates some properties of new theories of growth, for instance: endogenous R&D decisions, process innovations, and technological and knowledge spillovers between sectors and countries.

The software platform used to simulate the model is very user friendly. For example, it allows goal seeking by the policy analyst; that is, the possibility of calculating a new solution path dynamically while retaining useful information from prior solution paths. This is a particularly useful feature for creating projections and is accomplished through the IODE software developed by the Federal Planning Bureau.

2. Quantitative Characteristics

NEMESIS is a large-scale econometric model for the EC 27 countries plus Norway (EC 27+; some developments are under way to introduce the United States and Japan); it comprises roughly 70,000 equations with all behavioural equations being econometrically estimated. Regions outside EC 27+ are represented as being exogenous, with some distinction being made between ten world regions. Each EC 27+ country is fully modelled and is essentially linked to others through external trade.

The main exogenous variables are:

- **World assumptions**: interest (long- and short-term) and exchange rates; activity variables for the rest of the world; wholesale and commodity prices
- **Demographic assumptions**: total population; population structure and labour force
- **National assumptions**: interest (long- and short-term) and exchange rates; taxation policy (indirect and direct taxes, social security benefits and contributions); government expenditures (defence, health, education, others)
- **Energy-environment assumptions**: excise duties; tax rates (carbon and energy taxes)

The model covers 30 sectors (see Table 1) and 27 consumption categories. Principal sources for the data include: Eurostat, OECD, IEA databases, as well as national sources.

3. Main Characteristics

One of the innovations introduced with NEMESIS is found in the supply side that was developed for the model (more detail will be given in section 4). It uses the dual approach and is derived from the ”Generalized symmetric McFadden” cost function proposed by Diewert and Wales [1]. It was adapted to account for **quasi-fixed factors** with internal adjustment costs, as in Nadiri and Prucha [5]. This feature permits the modelling of adjustments in inputs such as capital to occur as a costly process that requires time to be fully implemented. The **sectoral demands** for energy, materials and investments are transformed into product demands using endogenous conversion matrices that map these demands into the outputs of industries. Firms determine **supply prices** by applying a mark-up to unit production costs. The rate of this mark-up is dependant on pressure from **monopolistic competition** in each sector and is related to R&D effort – which is itself dependent on a sectoral level of imperfect substitution of products (innovation):

1 Agriculture
2 Coal and Coke
3 Oil & Gas Extraction
4 Gas Distribution
5 Refined Oil
6 Electricity
7 Water Supply
8 Ferr & non Ferrous Metals
9 Non Metallic Min Products
10 Chemicals
11 Metal Products
12 Agr & Indus Machines
13 Office Machines
14 Electrical Goods
15 transport Equipment
16 Food, Drink & Tobacco
17 Tex., Clothing & Footwear.
18 Paper & Printing Products
19 Rubber & Plastic
20 Other Manufactures
21 Construction
22 Distribution
23 Lodging & Catering
24 Inland Transports
25 Sea & Air Transport
26 Other Transports
27 Communication
28 Bank, Finance & Insurance
29 Other Market Services
30 Non Market Services

Aggregate consumption is dependent on expectations of lifetime earnings but with a slow adjustment to changes in current income – implemented using an error correction

model (ECM).[11] **Total earnings** are a function of regional disposable income, a measure of wealth for the households, interest rates and inflation (in the dynamic equation only). Variables covering child and old-age dependency rates are also included in an attempt to capture any change in consumption patterns caused by an **aging population**. The **unemployment rate** is used, in the short-term equation (only), as a proxy for the degree of uncertainty in the economy. Due to the lack of available data on **household wealth**, investment in dwellings was used as a proxy for the housing stock. Consistent with the other behavioural equations, the **disaggregate consumption** module is based on the assumption that there exists a long-run equilibrium but rigidities are present which prevent immediate adjustment to that long-term solution. Again, an ECM specification is used to represent that adjustment process: the econometric equation is derived from the theory of rational consumers, with the restrictions imposed by it implemented in a flexible manner. Altogether, the **total aggregate consumption** is indirectly affected by 27 different components through their impact on relative prices and total income (to which demographic changes are added).

The allocation of consumption is done through an assumption of **group-wise separability**, meaning that the consumer faces a decision problem in several **stages**. In a **first stage**, the representative consumer decides how much he/she will spend on durable and complementary non-durable goods on the one hand, and non-durable goods on the other hand. In a **second stage**, he/she decides how to spend the money allocated in the first stage within each group, e.g., how much of the amount dedicated to the durable goods will be allocated to clothing, household utilities and transportation. Transportation includes public transportation, equipment (such as cars) and energy, divided into petrol, heavy fuel and oil. A **third decision stage** takes place in the non-durable goods group. It consists of the choice between necessities (including food, beverages, tobacco, education, rent, health, electricity and other expenditure items) and luxuries (including communication, tourism and domestic services). Once these decisions are made, the demand for each category is allocated to product demands (i.e., the output of firms) using conversion matrices.

The **wage equation** is based on a theory of the wage-setting decisions made by utility maximising unions. The unions derive utility from **higher levels of employment** in the sector and from **higher real consumption wages** (relative to wages outside the union), subject to the labour-demand constraint imposed by profit-maximisation by the firms. The implication of this form of the wage equation is that conditions in the labour market are critical for determining wages (in the adjustment process, price levels are also important). Indeed, the real wages in a given sector will **rise** if there are: productivity shocks[12], changes in the unemployment rate, or changes in the real wage outside that sector.

All **trade** is treated as if it takes place through two channels: intra-EU, and trade to the rest of the world. Data availability was an important factor in this choice – it allowed an emphasis to be put on intra-EU trade flows, which are a large portion of the total trade in

[11] Many of the adjustments processes modelled in NEMESIS are specified as ECM. This allows the model's long-term properties to be consistent with some economic fundamentals, while the short-term properties are allowed to reflect other considerations.

[12] In the current version this effect is bypassed.

the EU. One caveat worth mentioning is that, while it is possible to identify **volumes** for intra- and extra-EU trade, it is not the case for obtaining **prices** from the databases.

The intra- and extra-EU **export volume** equations can be separated into two components, income and prices. The **demand effect** is captured by: a variable representing economic activity in the rest of the EU for intra-EU trade; and a variable representing economic activity in the rest of the world for extra-EU trade (which is exogenous in the current version of the model). **Prices** are split into two sources of impacts in each of the two equations (intra- and extra-EU trade). For intra-EU trade, they are: the price of exports for the exporting country and the price of exports in other EU countries. For extra-EU trade, price impacts come through: the price of exports for the exporting country, and a rest-of-the-world price variable. The **stock of R&D** in a country (which, in NEMESIS, is taken relative to the total stock of R&D in Europe in a particular sector) is also included in the export equation in order to capture the role of innovations in trade performance and structural competitiveness.

The **import volume** equations are the same for both intra- and extra-EU trade. The **demand effect** is captured through domestic sales by domestic producers, while the **price effects** are represented in both the import price, as well as the price of domestic sales by domestic producers. The **stock of R&D** is again included to allow for the effects of innovations on trade performance.

The **import and export prices** result from an **arbitrage** between firms engaging in competitive behaviour and those pricing by mark-up – implying that prices do not exactly equal marginal cost. All **empirically based** equations of the model (except for the supply side) are estimated in an ECM framework.

4. The Supply side

Two original features that are worth emphasising in the supply side of NEMESIS include:

1. All factor demands are derived from a flexible functional form called the "Generalized symmetric McFadden" cost function.
2. Research and Development engaged by firms is a factor production factor that allows efficiency gains.

Regarding (1), the cost function has a representation under the flexible accelerator form (see [4] and [6]) with straightforward expressions for factor demand estimation and implementation in NEMESIS (see [2,3] for more details). The cost function uses three variable factors (Labour, Energy and Materials) and two quasi-fixed inputs (physical and R&D Capital).

Regarding (2), the firm's R&D effort will permit an increase in the total factor productivity (TFP) of its inputs, and thus to be more competitive in their market. R&D effort is modelled as dependent on market conditions such that firms increase effort when faced with adverse conditions.

The five equations were estimated simultaneously for each sector using pooled panel estimation techniques. Most parameters were constrained to have a common estimated value for all countries, while others (constants, etc.) were allowed to be differentiated by country. The use of panel estimation techniques makes maximum use of short time series (here 1981-1996). The use of a flexible functional form for the production/cost equation permits different elasticities and adjustment speeds for production factors in each country, even though some parameters are common (see [3] for estimation results, elasticities and adjustment speed of factors demands).

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Tables

Figures